

New Scientist

WEEKLY 30 April 2022

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INVASIVE SPECIES?**

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**DNA BUILDING BLOCKS
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How to GROW YOUNGER

Why our bodies get
old – and new ways
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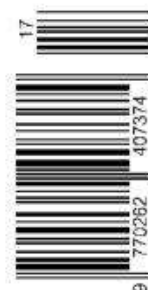


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Neanderthal Origins: Southern France

Step back in time on a journey to the key Neanderthal and Upper Palaeolithic sites of southern France between Bordeaux and Nice with archaeologist Rebecca Wragg Sykes. See some of the oldest traces left by ancient humans: stone tools, cave paintings and skeletons that have changed the way we think about Neanderthals. From 10 June or 16 September 2022 for 10 days. The cost is £3149.

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Weekly

Ever wondered what a rainbow sounds like? Or what happens if a rat's whiskers are played like a harp? Tune in to find out. The team also discusses a particularly bonkers theory of consciousness and scrutinises the latest report from the Intergovernmental Panel on Climate Change. Plus, find out which pop star just had a millipede named after them.

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Online event



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Say what? How we went from apes to sophisticated speakers

Podcast



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Colourful music What does a rainbow sound like?

Video

Breaking the news

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[youtube.com/newscientist](https://www.youtube.com/newscientist)

Newsletter

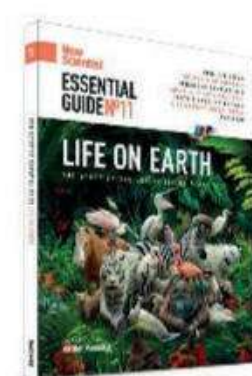
Fix the Planet

Chief reporter Adam Vaughan discusses the recent announcement of a new school qualification in natural history, or "saving the world" as some have dubbed it, that can be taken by students aged 14 to 16 in England, Wales and Northern Ireland. What impact will the two-year GCSE course have?

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Podcast

"I made a clip of *Ring a ring o' roses* played on a harp made with rat's whiskers"



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Follow the pseudoscience

Politicians should stop using science-sounding concepts to sell unscientific policies

IF YOU have a tricky bit of policy you need to sell, try reaching for some scientific words – whether or not research actually backs up your claims.

This tactic has been a favourite of the UK government in recent years. At the start of the covid-19 pandemic, it resisted calls for social distancing measures, as had already been implemented in some other countries. The reason given was that policies such as lockdowns would be unworkable because people would experience “behavioural fatigue”, a sciencey-sounding concept supposedly based on research in psychology, but which scientists advising the government later disowned. “If you look in the literature, you won’t find it because it doesn’t exist,” one told the BBC in July 2020.

Now, the UK government is using the

same playbook for its new policy towards asylum seekers, which calls for “scientific methods” to assess whether those who are unaccompanied and say they are children are under 18 (see page 8). These are age-assessment methods with a veneer of science, involving X-rays or

“Government science must truly be science, not just political spin”

DNA methylation, that probably sounded fantastically scientific in the corridors of power, but when it comes to proving they work – what some might call “the science bit” – they are sorely lacking.

It’s not just politicians in the UK who wield the stamp of pseudoscience. The European Union’s peculiar carbon

accounting allows it to claim that biomass is a renewable energy source, when in plain language it generally means burning trees, a practice that actually fuels climate change. And last year, law-makers in Texas banned abortion beyond six weeks of pregnancy if a doctor could detect a “fetal heartbeat”, a medical-sounding term that doctors say has little medical meaning for a bundle of cells.

It is right that democratically elected politicians should make decisions by weighing scientific evidence as a factor, rather than simply “following the science”. But as Fiona Fox, head of the UK’s Science Media Centre, says on page 27, government science must truly be science, not just political spin. Throwing in a few choice phrases to “science things up” isn’t good enough. ■

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Parasitic DNA

Frogs acquired selfish genetic sequences from snakes **p10**

Risky business

How some male spiders escape being eaten by mates **p15**

Molecular engine

Tiny machine parts have been created from proteins **p16**

'Viking skin'

Macabre adornments on churches aren't what they seem **p19**

Fly on the wall

Drones can save power by perching like insects **p20**



SAMEER SEHGAL/HINDUSTAN TIMES/SHUTTERSTOCK

Wheat processing at a market in Punjab, India, on 21 April

Climate change

Severe Indian heatwave

Vulnerable people and wheat harvests are at risk from temperatures forecast to soar above 40°C, reports **Adam Vaughan**

MORE than a billion people are facing a severe heatwave across India this week, which will have wide-ranging consequences for the health of the most vulnerable and will damage wheat harvests.

Temperatures in the mid-to-high 40s°C are forecast for much of the country in the coming days, with the India Meteorological Department (IMD) issuing heatwave alerts for several states.

The UK Met Office says that temperatures are currently above average in India and that this will probably continue into the coming week. India is entering a season ahead of the monsoon's arrival when heatwaves are common, the Met Office says, but this year it follows a period

of unusually early hot conditions.

March was record-breakingly hot, with a national average maximum temperature of 33.10°C, beating the 33.09°C set in March 2010. R K Jenamani, head of the national weather forecasting centre at the IMD, says that the recent heatwaves have been notable because they occurred during a La Niña weather pattern – which usually has a cooling effect globally – while the 2010 records took place during an El Niño, which has a warming effect.

"It's really bad," says Arpita Mondal at the Indian Institute of Technology Bombay, Mumbai. She says high humidity in the city means that temperatures around 32°C feel more like 38°C. "It's very

tiring and stressful," she adds.

What is notable is how early the heatwaves have come, she says. They are also widespread, baking almost the entire country rather than just India's two usual hotspots, the central north-western region and the south-east.

"While March to June have always been very hot, climate change is fuelling extreme temperatures"

The recent heat is likely to have been exacerbated by climate change, says Mondal, though it is too early for any specific research attributing the event to global warming. She points out that last year's Intergovernmental Panel on

Climate Change report found heatwaves across land globally had become more intense and frequent, with high confidence that human activity is to blame.

Local weather patterns are playing a role, too. Jenamani says there has been an absence of storms that can bring rainfall from the Mediterranean to northern India, with just five occurring in March and all of them dry. March also saw lower than usual thunderstorm activity over most of India, he adds. R Krishnan at the Indian Institute of Tropical Meteorology says the unexpectedly prolonged La Niña may also be contributing.

Research suggests India is seeing a growing number of extreme heat days. Kim Knowlton at the non-profit organisation NRDC says an ongoing update of a study by an IMD team found 600 heatwave days between 2011 and 2020, compared with 413 between 1981 and 1990. "While the months of March to June have always been very hot, climate change is fuelling more extreme temperatures," she says.

The impacts go beyond making life almost unbearably hot for people working outdoors in everything from construction to rickshaws and farming. The heat also threatens wheat harvests at a time when global supplies of the crop are already under pressure due to Russia's invasion of Ukraine.

Heatwaves have hit India's biggest wheat-producing states, Haryana, Uttar Pradesh and Punjab, with officials in the latter warning production targets will be missed after wheat was found shrivelled. Temperatures above 34°C cause heat stress for wheat, and future climate change is projected to reduce India's wheat yields. ■

Flawed asylum science

Scientific ways of determining the age of a person don't exist, so UK plans to send adult asylum seekers abroad could put children at risk, reports **Jason Arunn Murugesu**

HEALTH bodies and charity workers fear that the UK government's plan to send adult asylum seekers to settle in Rwanda, rather than allowing them to settle in the UK, will inadvertently lead to unaccompanied children being deported. This is because, despite the government's proposed Nationality and Borders Bill calling for "scientific methods" to confirm that child asylum seekers aren't adults, experts say there is no such way to determine someone's age.

Age assessments aren't mere form filling. Unaccompanied children arriving in the UK need to enter education and be found a foster family as soon as possible. There are also fears that adults may

"There is no medical or psychological test which can definitively state a person's age"

claim they are children in the hope of being treated more favourably by the UK's asylum system.

But many people who flee their home countries can't prove their age. They may have lost their documentation in conflict, never had a birth certificate in the first place or simply be from a culture that doesn't celebrate birthdays.

Last year, there were 3762 claims for asylum in the UK made by unaccompanied children, but officials from the country's Border Force or local councils disputed 2517 of them and ordered an age assessment. Around 60 per cent of these were judged to be at least 18, and so adults.

Such assessments are controversial. Several charity workers and lawyers have told *New Scientist* that caseworkers are using pseudoscience to help justify their decisions on whether an asylum seeker is a child or an

adult. Lawsuits have been brought against the UK's Home Office in the past few years due to officials judging child asylum seekers to be adults and putting them into hotels unsupervised, without safeguarding measures.

Current age assessments in the UK are largely conducted by local government social workers and are based on a series of interviews with the asylum seeker as well as judging their appearance and demeanour. This process can be subjective and lacking evidence.

"I was so stressed [by the whole process]," says Jerome*, an asylum seeker who arrived in the UK in 2020 with no identification. Jerome says he was 16 when he arrived in the country, but Border Force didn't believe him.

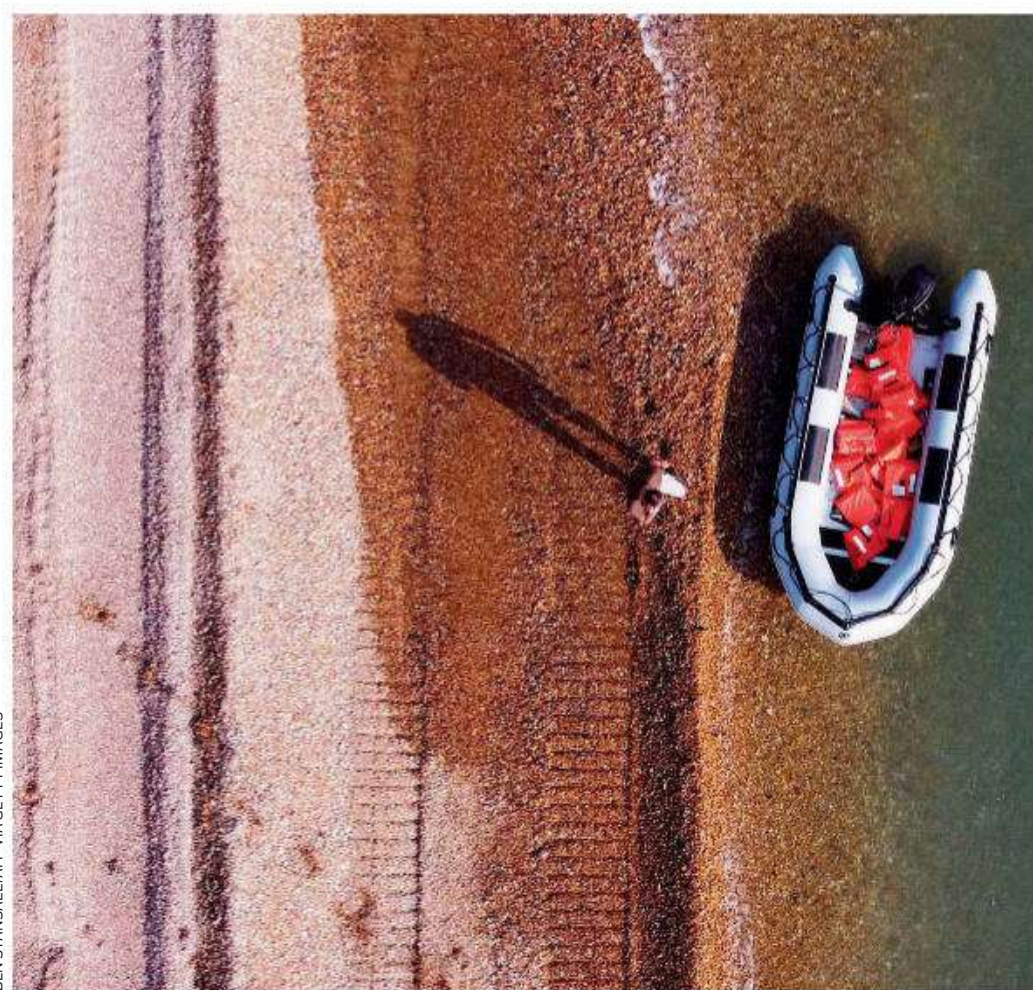
After three months and four separate interviews, two social workers claimed that Jerome was lying about his age and judged that he was aged between 19 and 22.

New Scientist has seen documents produced by the social workers to justify this assessment. In the "appearance and demeanour" section, they claim that because Jerome's skin didn't look youthful, he was unlikely to be 17.

The report also suggests that because Jerome had broad shoulders and a pronounced Adam's apple, it was likely that he had "completed puberty". In order to claim that Jerome's broad shoulders were a sign of adulthood, the report linked to a website that instructs readers on how best to draw the human body.

"It's complete pseudoscience," says Jerome's independent charity social worker*. "It's medieval."

But Jerome's case isn't unusual. Bob*, a charity worker, says he worked with a 15-year-old asylum seeker* last year who was asked to tell social workers where exactly his body hair was. In another case,



An abandoned inflatable boat used by migrants to reach Dover, UK, in 2020

3762

Asylum claims made by unaccompanied children in the UK in 2021

a woman* from an East African country was told she couldn't be 17 because her hips were too wide for teenage women from that region.

Bob also had a case in which the facial hair of an asylum seeker* from a north-eastern African country was taken as evidence that he was over 18 because the assessors judged that men from the region don't develop facial hair until late adulthood. "It's just plain wrong and racist," says Bob. "I believe age assessments are one of the most disturbing aspects of the entire asylum system [in the UK]."

Bob says the UK's new migration plans risk children being wrongly assessed as over 18 and quickly moved to Rwanda. "The Home Office could decide to take the precautionary approach not to remove anyone whose age has been disputed – but I can't see this happening," he says. "They'd say that everyone will then claim



to be a child at the border.”

The Home Office told *New Scientist* that it won't send unaccompanied children to Rwanda. “Everyone considered for relocation will be screened, interviewed and have access to legal advice,” says a Home Office spokesperson. “Decisions will be taken on a case-by-case basis and nobody will be removed if it is unsafe or inappropriate for them.”

The spokesperson also said the current age assessment method is “very subjective” and that measures put in place through the Nationality and Borders Bill will stop adults who are seeking asylum claiming to be children.

In January, the Home Office launched a scientific committee to look at alternative age assessment techniques. The committee is looking at three main methods, according to a source with knowledge of the matter who

spoke to *New Scientist* on condition of anonymity.

The first method, dental X-rays, works on the assumption that teeth mature at a constant rate and that all teeth, except the third molars – also called wisdom teeth – are fully mature by the age of 20. The technique is used in countries like France and Sweden to assess the ages of asylum seekers.

But the British Dental Association (BDA) has called the methodology inaccurate, saying that children as young as 16 can have mature wisdom teeth, while some people never develop them at all.

“Dental age checks fail basic standards on accuracy and ethics,” says Eddie Crouch at the BDA. “If ministers go down this path, it seems inevitable that some child refugees risk being handed a one-way ticket to Rwanda.”

The second method involves taking X-rays of the wrist bone and comparing the image to the X-rays of other similarly aged people. A briefing note on the topic published on 15 March by the Parliamentary Office for Science and Technology said the method should be used with caution because we don't really know how trauma or malnourishment, both common in asylum seekers, may affect wrist bone density.

“There is no medical or psychological test which can definitively state a person's age,” says Zoë Greaves at the British Medical Association (BMA). “In addition, the use of procedures such as radiographs of bones and teeth to determine age is not only unreliable but also poses a risk [from X-ray exposure] to individuals forced to undergo the procedure.”

“The BMA believes that it is not ethical for doctors to use their clinical skills to take part in an

age-assessment process that results in vulnerable and traumatised people being sent to an offshore facility,” says Greaves.

The scientific committee is also investigating whether DNA methylation can be used to assess a person's age. This is the chemical modification of DNA that happens throughout our lives and studies

“It seems inevitable that some child refugees risk being handed a one-way ticket to Rwanda”

have shown that the “biomarkers” of this process, found in blood or saliva samples, can be used to estimate a person's age. But Eugénia Cunha at the University of Coimbra in Portugal, who studies the technique, says the results aren't accurate enough to be used in real-world age assessments.

The source with knowledge of the Home Office's scientific committee says they believe the department intends to go ahead with some of these methods in the coming year, especially dental X-rays.



MARCO OHMER/ALAMY

Wrist X-rays are used for age assessments in the European Union

The Home Office didn't confirm or deny this before publication.

Using these kinds of biological signs to determine age may appear to be accurate and impartial, but they aren't, says the source. The main benefit is cost. “If you ignore the fact that they get the answer wrong quite a lot of the time, it's much cheaper than a social worker assessment,” says the source.

So if current age assessments are flawed, and the government's proposed scientific methods are also unreliable, what is the solution? Jo Schofield has 10 years' experience conducting age assessments for local councils. She has since set up an independent firm called Immigration Social Work Services in the UK for whenever someone wants to challenge an official assessment.

“I believe social workers can do this work if they are trained properly,” she says. “We do 9-hour assessments which are trauma-informed and give the asylum seeker the benefit of the doubt.” She says budget cuts, a lack of training, overwhelming caseloads and a culture of disbelief have led to social workers conducting age assessments too hastily. Schofield estimates that a properly carried out assessment can cost a few thousand pounds, while those that may have been done incorrectly, resulting in legal challenges, can cost £45,000.

In February, Schofield set up a qualification for age assessment that any social worker can take. She believes that such holistic assessments are the best way to assess a young person's age. “It just needs to be done properly,” she says. ■

*names have been changed and specifics left out to protect people's identities and because legal cases are ongoing



Biology

'Selfish' genetic sequences jumped from snakes to frogs via parasites

Jake Buehler

MANY snakes make meals of frogs, but some appear to be transferring their DNA into the amphibians as well. A genetic analysis suggests that parasites shared between snakes and frogs may facilitate the movement of genetic material from one species to another.

The "horizontal" transfer of DNA between species was long considered a rare event that took place only between microbes, but there is growing evidence that the process has been going on all over the tree of life.

Genetic sequences called transposons – also known as "jumping genes" and sometimes described as selfish or parasitic DNA – can move around in a genome. Some of these, called retrotransposons, expand in the genome by copying and pasting themselves.

One known as Bovine-B (BovB) now makes up more than 18 per cent of the cow genome, but originally came from a snake through horizontal DNA transfer 40 to 50 million years ago.

Almost 10 years ago, Atsushi Kurabayashi at the Nagahama

Institute of Bio-Science and Technology in Japan found BovB in the genomes of frogs from Madagascar. The sequence was a 95 per cent match with viper BovB.

Suspecting that it had jumped from snakes to frogs, Kurabayashi and his colleagues have now analysed the DNA from 106 snake species, 149 frog species and 42 species of their shared parasites – like leeches and ticks – from

***Boophis pyrrhus*, a frog from Madagascar that picked up BovB**



RYOSUKE KAKEHASHI

around the world. The researchers screened the samples for BovB and charted its history of hopping between species.

They estimate that BovB jumped from snakes to frogs at least 54 times between 85 million and 1.3 million years ago. Madagascar seems to be a hotspot for the transfers: 91 per cent of the island's frogs have BovB and it has invaded their genomes 14 times within the past 50 million years. In that same period, this only happened once in mainland Africa (*Molecular Biology and*

Evolution, doi.org/hrjf).

Various parasites may be aiding the process, since several of the parasite genomes contained BovB sequences close to those in snakes. Half the parasite species in Madagascar had BovB in their genomes, compared with less than 3 per cent in East Asia.

The findings hint that the horizontal transfer of DNA can be affected by the prevalence of parasites in a region, just like some diseases, says Kurabayashi.

James Galbraith at the University of Exeter in the UK says he is "blown away" by the findings and is interested in whether other biodiversity hotspots also show high rates of horizontal transfer or if there is something special about Madagascar.

Atma Ivancevic at the University of Colorado Boulder cautions that key intermediate species in the BovB chain could still be missing. "All we see is the end result of BovB presence in a snake and frog, or leech and frog, or tick and snake, but it's very hard to track how BovB elements ended up in these species," she says. ■

Climate change

China still investing heavily in new coal-fired power plants

CHINA was responsible for more than half of the new coal power station capacity being built around the world last year, showing how much the country is propping up one of the worst drivers of climate change.

Nearly 200 countries pledged a "phasing down" of coal at the COP26 climate summit last year. But figures in a report by the non-profit organisation Global

Energy Monitor show that is nowhere near being realised yet. Globally, the number of coal power stations is actually growing as new constructions more than offset the closure of old plants.

Building of new coal-fired plants is occurring overwhelmingly in Asia, with China accounting for 52 per cent of the 176 gigawatts of capacity under construction in 20 countries last year. The global figure is barely changed from the 181 GW under way in 2020, despite analyses showing that no more new coal projects can be built if climate goals are to be met.

"It's a mixed story. Everywhere outside of China, plans for new coal-fired power plants have been scaled back dramatically," says one of the report's authors, Lauri Myllyvirta at the Centre for Research on Energy and Clean Air.

"However, Chinese firms have continued to announce new coal-fired power stations and there is very clear government backing for that. That's a worrying sign."

"Chinese firms have continued to announce new coal-fired power stations. That's worrying"

There is no expectation that China will change course on coal this year, says Myllyvirta, though he says its promise last year to stop financing coal projects overseas has already seen 13 GW of plants cancelled. He expects a further 37 GW to be cancelled this year because of the move.

A record amount of coal was burned last year, prompting talk of a "coal comeback". But Myllyvirta says it is "delusional" to think this is a "new normal", arguing the fuel only became temporarily attractive because gas got so expensive. ■ Adam Vaughan

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Environment

Insects and lab-grown meat could reduce food emissions by 80 per cent

Michael Le Page

SWAPPING the meat and dairy products that make up a typical European diet for insect meal and laboratory-grown produce could cut food-related greenhouse gases, as well as water and land use, by over 80 per cent, a study suggests. Food production has huge environmental impacts, driving more than a third of all greenhouse gas emissions. Land clearance for farms is also a key cause of biodiversity loss.

To assess ways to lessen this impact, Rachel Mazac at the University of Helsinki in Finland and her colleagues have studied the potential effects of switching to “novel and future foods”.

“What we are looking at are foods that are novel in their production technology, like cultured meat or cultured milk,” says Mazac.

She is part of a group at the University of Helsinki that has been doing life-cycle assessments of the environmental impacts of such foods.

Her team used the analyses to calculate the potential benefits of switching to these foods,



SHUTTERSTOCK/STOCKCREATIONS

An insect burger made of fried mealworms

assuming people are willing to do so, compared with foods that are typically consumed in Europe.

The results suggest that an “optimised diet” of novel foods could cut greenhouse emissions by 83 per cent, water use by 84 per cent and land use by 87 per cent (*Nature Food*, doi.org/hrh8).

“We are seeing some pretty significant reductions in impacts,” says Mazac.

The team also found that swapping to a vegan diet would cut greenhouse emissions by 84 per cent, water use by 82 per cent and land use by 80 per cent.

Opting for lab-grown meat, rather than a vegan diet, could allow many people to eat foods that more closely resemble their current diet. “It would be a way for someone to consume their fast-food burger, but save on land use and water use and global warming potential,” says Mazac.

Some of these products are already widely available, such

as Quorn, grown from fungal cells. Others, such as lab-grown meat, are only produced on a small scale. The team’s analysis also included some foods not widely eaten in Europe, such as insects, kelp and the alga spirulina.

Speaking of the results, Tim Lang at City, University of London, says: “It’s almost too good to be true.”

If the findings are correct, the research has immense policy implications, he says. But Lang thinks the environmental benefits won’t come about through consumers making voluntary changes to their diet. They will only play out if governments and companies essentially force these foods on people, he says.

Not everyone is convinced by how the research was carried out. “[The study] makes a huge number of very optimistic assumptions,” says Erik Millstone at the University of Sussex, UK. Even if the analyses of the “future foods” currently produced in small quantities are correct, the analyses might not apply to mass-produced versions, he says. ■

Communications

Copper wire could achieve gigabit broadband speeds

THE copper telephone wire already in use across the UK might be able to achieve data rates three times higher than currently seen with fibre-optic cables.

Ergin Dinc at the University of Cambridge and his colleagues say that twisted pairs of copper wire, of the type used for decades as telephone lines and now repurposed for broadband internet, can support a frequency five times

higher than is currently used, which would dramatically improve data transmission rates. Above that limit, the team found that the wire essentially acts as an aerial and transforms any signal sent along it into radio waves that dissipate before reaching their destination.

“These cables are actually very old, invented by Alexander Graham Bell, and since then no one has looked into the theoretical limits,” says Dinc.

Fibre-optic cables carry groups of photons to represent data. They typically operate at 1 gigabit per second, but theoretical speeds

could be thousands of times higher.

In copper wiring, the signal is sent by an electrical current running along the entire length of cable, and the data transmission rate is limited by how quickly the current

“These cables are very old and no one has looked into the theoretical speed limits”

can be changed. Existing copper broadband connections operate at a frequency below 1 gigahertz, where the current is changed a billion times a second, but the team found

that this can theoretically be raised to 5 gigahertz using a small, cheap component called a balun (*Nature Communications*, DOI: 10.1038/s41467-022-29631-8).

Dinc doesn’t think this will translate directly to a fivefold increase in data transmission, because the error rate increases at higher frequencies, but 3 gigabits per second is feasible, he says. That is triple copper’s theoretical limit, although in practice, most people with copper wire broadband in the UK get speeds of at most 80 megabits per second. ■

Matthew Sparkes

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Origins of life

DNA bases found in space rocks

We have now discovered all four building blocks of DNA in meteorite samples

Carissa Wong

ALL four of the key DNA building blocks have now been found in meteorites, suggesting that space rocks may have delivered the compounds to Earth, contributing to the origin of life.

DNA has a spiral-staircase structure, in which each step consists of pairs of molecules called nucleobases. Two of these four nucleobases – adenine and guanine, which belong to a group of chemical compounds called purines – were first detected in meteorites in the 1960s.

Now, Yasuhiro Oba at Hokkaido University in Japan and his colleagues have discovered the remaining two DNA nucleobases, cytosine and thymine, known as pyrimidines, in several meteorites.

The team found the nucleobases in about 2 grams of rock from three meteorites: the Murchison, Murray and Tagish Lake meteorites. The Murchison and Murray meteorites, which hit Earth in the mid-20th century, are thought to date to at least 5 billion years ago. Like Earth, the Tagish Lake meteorite probably formed

4.5 billion years ago, and it hit our planet about two decades ago.

Oba's team ground each rock sample into a powder that was added to water, before using ultrasound waves to separate the particles into layers. The group then used mass spectrometry to identify compounds according to their molecular weight.

The Murchison meteorite, which fell in Victoria, Australia, in 1969

"There was a reason why cytosine and thymine in meteorites were never reported until now... these compounds are in very trace amounts, which required a method with the capability to measure such small amounts," says Michael Callahan at Boise State University in Idaho.

Could the compounds have come from contamination? In soil around the Murchison meteorite landing site in Australia, the relative amounts of nucleobases

differ substantially from those in the meteorite, suggesting that the rock's nucleobases came from space (*Nature Communications*, DOI: 10.1038/s41467-022-29612-x).

"I am convinced that the data is not reflective of terrestrial contamination," says Bradley De Gregorio at the Naval Research Laboratory in Washington DC.

Rocks containing nucleobases may have hit Earth between 4 and 3.8 billion years ago, in the Late Heavy Bombardment. This precedes the earliest known undisputed microbe fossils, which are about 3.4 billion years old.

Oba's team also detected a higher concentration of nucleobases in the soil the Murchison meteorite fell onto than in the meteorite.

"If these results are representative of typical pyrimidine concentrations in meteorites," says Callahan, "then [nucleobases present on] Earth would likely have been responsible for the emergence of genetic material rather than inputs from extraterrestrial delivery." ■



THE NATURAL HISTORY MUSEUM/ALAMY

Animals

Bloodworm's copper fangs could inspire new materials

THE venom-injecting jaws of sea creatures called bloodworms contain an unusually high level of copper – and now we know that a simple protein is responsible for these impressive fangs, which could inspire new ways of creating materials.

Herbert Waite at the University of California, Santa Barbara, and his colleagues have been studying the 2-millimetre-long jaws of the *Glycera dibranchiata* bloodworm,

which are made up of 10 per cent copper and last for the worm's entire five-year lifespan.

"You've got a little worm that's making a jaw that's as hard and stiff as bronze, and some ceramics as well – and they're doing this autonomically," he says.

The researchers used advanced molecular and mechanical analysis techniques and modelling to investigate the composition and detailed functions of the worms' jaws. They discovered that the composition is governed by a protein that controls a multistep process, which starts by binding copper from the environment, then mixing

it in an aqueous solution before separating it to produce a dense liquid that catalyses the conversion of an available amino acid into melanin (*Matter*, doi.org/hrh5).

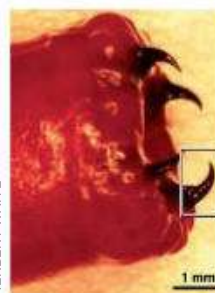
While melanin often serves as a pigment for colour traits in other animals, here it seems to make the bloodworm's jaws more

resistant to wear, says Waite.

The protein has a relatively simple structure, which is surprising because, in biochemistry, catalysts are usually based on much more complex proteins, and this protein does more than just catalyse. "It really does boggle the mind how a low-complexity system like that can do that many different basically unrelated tasks to come up with a composite material," says Waite.

The findings could trigger engineers to improve the design and manufacture of composite materials, like concrete and rubber-filled tyres, he says. ■

Christa Lesté-Lasserre



Bloodworm jaws are 10 per cent copper

HERBERT WAITE

Animal behaviour

Spiders catapult after mating to escape death

Sam Jones

AFTER sex, male orb-weaving spiders fling themselves away from females to avoid being eaten.

Shichang Zhang at Hubei University in China and his team first noticed this behaviour while studying the spiders in the mountains in Wuhan in 2019.

They investigated further in the lab by using high-speed cameras to capture the behaviour of 155 mating pairs of an orb-weaving spider (*Philoponella prominens*). Only three of the males didn't catapult after mating. All were captured and eaten by their partners. Males that catapulted survived.



Two *Philoponella prominens* spiders mating

To further test the necessity of this behaviour, the researchers blocked the males from catapulting. They, too, were all killed and eaten (*Current Biology*, doi.org/hrh7).

The males launch themselves at speeds of up to 88.2 centimetres per second, which Zhang says is impressive for a spider that is around 3 millimetres long. That is the equivalent of someone about 180 centimetres tall jumping 540 metres – roughly the length of five football fields – in a second.

William Brown at the State University of New York at Fredonia wonders if the escape strategy might also be used in response to other threats. "Have males co-opted a general anti-predator defence or is this uniquely an adaptation to reduce the risk of sexual cannibalism?" he says.

Zhang's team hypothesises that this behaviour evolved to signal fitness as mates. ■

Climate change

We can tell how much CO₂ in air is from burning fossil fuels

Michael Le Page

A WAY of directly measuring the carbon dioxide released by burning fossil fuels could help cities and countries monitor their efforts to reduce emissions in near real time.

"We are in a shrinking window of time to do this, so I think we really need to know what the situation is as quickly and as accurately as possible," says Penelope Pickers at the University of East Anglia, UK.

At present, governments and research organisations estimate countries' overall emissions based on data such as how much oil or gas has been sold. While initial estimates are often fairly rapid, it can take years to fully compile this information and estimates can vary hugely.

Measuring fossil fuel emissions directly would help confirm the accuracy of these inventory-based estimates and reveal more quickly if emission-reduction policies are working or not. It could also enable us to track how much specific cities or regions are emitting.

But such measurements are extremely difficult because plants take up or release varying amounts of CO₂ as the seasons change and weather shifts. It is like standing on a beach and immediately trying to tell whether the tide is going in or out, as waves are constantly coming and going.

So, while the long-term global rise in atmospheric CO₂ due to human activity – from around 280 parts per million before the industrial revolution to nearly 420 ppm today – is crystal clear, the short-term, regional picture is much less so.

Researchers have tried various ways of directly measuring fossil fuel emissions. One is to determine what



EYES35.PIX/ALAMY

proportion of atmospheric CO₂ is in the form of the radioactive isotope carbon-14, which isn't found in fossil fuels because it decays over time, and the oil and gas we use are millions of years old. But this requires the collection of samples in flasks, so continuous measurement isn't possible. What is more, some types of nuclear power stations emit carbon-14, obscuring the picture.

"We need to know what the emissions situation is as quickly and as accurately as possible"

Pickers's team has used an alternative approach based on measuring both atmospheric oxygen and CO₂ simultaneously. When plant matter is used as food, or it decays or burns, the ratio of the oxygen lost from the atmosphere to increased CO₂ is around 1:1.1. When burning coal, it is about 1:1.2 and for gas it is 1:2.

The researchers used measurements taken at the Weybourne Atmospheric Observatory on the Norfolk

Ratcliffe-on-Soar coal power station in Nottinghamshire, UK

coast to calculate emissions from the southern UK since 2020. They used machine learning to estimate how changes in weather and wind direction affect oxygen and CO₂ levels in the area.

The team was able to detect falls in fossil fuel emissions during the first and second covid-19 lockdowns in England (*Science Advances*, doi.org/hrg2). "Covid has been a great example of a quite sudden, abrupt change," says Pickers.

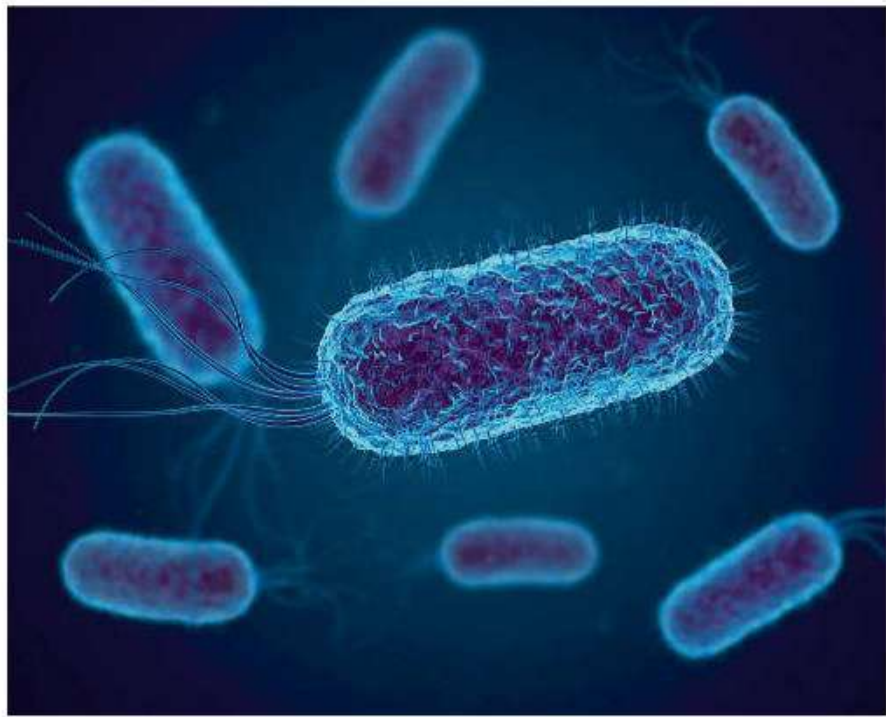
With a network of around four observatories, it would be possible to measure emissions from Britain, she says. More would be needed to monitor individual cities.

The study makes a strong case that the method is effective, says Brad Weir at the NASA Goddard Space Flight Center in Maryland. But building monitoring stations around the world would take a lot of time and money, he says. ■

Nanotechnology

Tiny machine parts made of self-assembled proteins

Michael Le Page



Molecular engines were created inside *E. coli* bacteria

The team made the machine parts by putting DNA coding for the custom proteins into *E. coli* bacteria, and then checked the structure of the proteins using a method called cryogenic electron microscopy.

This showed that the axles assembled correctly inside the rotors, and also revealed the different configurations that would be expected if the axles were turning (*Science*, doi.org/gpzm4f). But because cryogenic electron microscopy can only provide a series of still pictures, the team can't say for sure if the axles are rotating.

If they are, it would only be a random back-and-forth movement caused by molecules knocking into each other, a phenomenon called Brownian motion. The team is designing more parts to drive the motion in one direction and create a rotary engine, says Baker.

"I am pretty blown away," says John Moulton at the University of Maryland. "As far as I am aware, it's the first time anyone has come close to designing a protein machine." Groups have designed novel single proteins before, says Moulton, but not such complex assemblages.

"I am very impressed with the structural detail," says Pierre Stömmmer at the Technical University of Munich, Germany, who was part of a team that last year unveiled a piston made of DNA. Two other groups have created moving machines made of DNA, he says. "I will be waiting eagerly to see how the group will implement an energy input to the system to drive the motion in one direction." ■

THE first components of a molecular engine – self-assembling axles and rotors made of artificial proteins – have been created from scratch.

"We are starting very simply," says Alexis Courbet at the University of Washington in Seattle. But as his team creates more parts, it will become possible to combine them into ever-more-sophisticated nanomachines, he says.

"There could really be an incredible number of applications," says team member David Baker, also at the University of Washington. Nanomachines could one day unclog arteries or repair damaged cells, he says.

There are already countless molecular machines on Earth. Living organisms are essentially made of protein machines, including innumerable forms of rotary engines, such as the "tail," or flagellum, of some bacteria.

But because these have been optimised by evolution for specific roles, it is hard to adapt them for other tasks, says Baker. "What we've found is that if you

go back to the start and try designing everything from first principles, you can get much, much further." To achieve this, Courbet, Baker and their colleagues designed proteins unlike any found in nature.

Proteins are chains of amino acids. Natural proteins are made of about 20 different amino acids, and their sequence determines the protein's structure. Predicting what

"As far as I am aware, this is the first time anyone has come close to designing a protein machine"

shape a sequence will fold into has been a challenge for decades, but recently there have been huge advances thanks to deep-learning software.

Courbet designed several different versions of protein axles and rotors using a suite of software called Rosetta developed by Baker's group. This includes RoseTTAFold, similar to the AlphaFold protein structure prediction system made by UK AI firm DeepMind.

Climate change

Rock dust can help UK meet net-zero carbon removal goal

Adam Vaughan

SPREADING rock dust on the UK's farmland could provide almost half the amount of atmospheric carbon dioxide removal the nation needs to meet its binding net-zero target for 2050, according to a new analysis.

The recent report by the Intergovernmental Panel on Climate Change said the need to remove vast amounts of carbon dioxide from the air is "unavoidable" if the world's climate goals are to be met.

Enhanced rock weathering, a process in which rocks such as basalt are ground up to increase their surface area and accelerate the natural reactions through which they absorb carbon from the air, is thought to be a potential large-scale option for those removals.

Now, David Beerling at the University of Sheffield, UK, and his colleagues have analysed the approach. They found that,



Rock dust being sprayed on a field before planting

by mid-century, sprinkling rock dust on UK fields could allow for the absorption of 6 to 30 million tonnes of CO₂ a year. That is up to 45 per cent of the carbon removals from the atmosphere needed for the country's net-zero target (*Nature Geoscience*, doi.org/hrmx).

"It's got overlooked potential to help with the UK net-zero-by-2050 commitment," says Beerling.

What is more, the ground-up rock can act as a fertiliser, boosting crop yields. While Beerling's team found that the technique was more expensive than tree planting, it is about half the cost of "direct air capture" machines. ■

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Archaeology

'Viking skin' nailed to medieval church doors in England is actually animal hide

Joshua Howgego

PATCHES of skin supposedly flayed from Viking raiders and attached to the doors of some English churches are actually animal hides, a genetic analysis has revealed.

At least four medieval churches in England have remains of these so-called daneskins. The most well-known example is from St Botolph's church in Hadstock, near Cambridge. According to local myth, St. Botolph's macabre adornment was taken from a Viking after they attempted to pillage the church, the door of which dates back to the 11th century.

To learn more, Ruairidh Macleod at the University of Cambridge and his colleagues analysed skin fragments from three of the four known churches: St Botolph's; St Michael & All Angels Church in Copford, near Colchester; and Westminster Abbey in London. Daneskin is also attached to a door in Worcester Cathedral, but Macleod doesn't yet have permission to test this sample.

The team analysed five daneskin samples from the three churches' doors, which were either



SAFFRON WALDEN MUSEUM

"Daneskin" and a hinge from St Botolph's church in Hadstock, UK

taken from the doors directly or were held in a museum. Collagen, a key skin protein, was analysed via ZooMS, a technique that identifies animal species according to their collagen.

The results, presented at the 2022 UK Archaeological Sciences Conference in Aberdeen, reveal that none of the skins came from a Viking. Two of the churches' daneskins were actually cowhide, while the Copford skin came from

a horse or donkey, which have very similar collagen fingerprints to each other.

This supports an old hypothesis that these skins were put on church doors to make them more attractive, says Jane Geddes at the University of Aberdeen.

A medieval author known as Theophilus Presbyter, thought to have been a monk born around 1070, wrote the book *On Divers*

"Church doors had an immense symbolic meaning – these were the gateways to paradise"

Arts, which gives instructions on how to build churches. It states that wooden doors should be covered with animal hide, before being smoothed and whitened, to show off the doors' intricate ironwork.

"Church doors had an immense symbolic meaning – these were the gateways to paradise," says Geddes. "The skins mean the ironwork would have been sitting on smooth leather; it would have looked like a casket or treasure chest."

The origin of the Viking folklore is unclear, but the myth persisted for centuries. In the 1970s, Ron Reed, an expert on leather at the University of Leeds, UK, analysed the St Botolph's skin at Geddes's request. Reed mistakenly concluded that the skin was human, probably from "a person with fair or greying hair", supporting the legend that it came from a flayed Viking after they attempted to pillage the church.

"The story is that the villagers were not very happy about this, so they proceeded to kill the Viking, flay him and nail his skin to the church door as a warning to other people," says Macleod. ■

Technology

Brakes instead of motors make robot arms more efficient

ROBOTIC limbs that are controlled by electrostatic brakes rather than many motors could lead to a new generation of lightweight robots that use far less power than existing designs.

Robots usually have one or more motors for every joint to control movement, but Patrick Lancaster at the University of Washington in Seattle and his colleagues have

created simple brakes that enable joints to be frozen or released in precise combinations so that a single motor can power a limb with as many as 10 joints.

Each electrostatic brake is made of two thin sheets of metal separated by an insulating layer. When no voltage is applied across the sheets, they move freely over each other, but when a voltage is present there is an electrostatic attraction between the plates, which clamps them tightly together so that friction stops movement.

Lancaster says that by carefully

controlling which joints are braked, a single motor can be used to move a robot limb to any position.

Unlike a limb that requires multiple motors, one with the electrostatic devices may take longer to get into position as it brakes certain joints, runs the motor and repeats the process to make additional movements.

However, while it lacks the direct and decisive motion of a heavily motorised robot limb, it has the advantage of allowing for a much cheaper, lighter and more energy efficient version

(arxiv.org/abs/2204.02460).

Lancaster says that each brake uses around 1000 times less power than a comparable motor for controlling a joint would. But he concedes that electrostatic brakes are "nowhere near" ready to use in commercial robots yet.

"One of the challenges we've been working on is the strength of the brake. It's highly dependent on the thickness of this insulating layer. But you can imagine that if you try to use thinner materials, they're less mechanically robust," he says. ■

Matthew Sparkes

Technology

Surveillance drone saves power by crashing into walls

Matthew Sparkes

SMALL drones used for surveillance can monitor events for longer by attaching themselves to a wall and powering down their rotors to extend battery life.

Jeffrey Mao at New York University and his colleagues came up with the idea and built a prototype from commercially available parts. Mao says the drone typically has a flying time of just 20 minutes before its batteries run out. But by having the drone stick to a wall, its battery life can be extended by around 12 times, reaching up to 4 hours.

The prototype has Velcro on its undercarriage, which sticks to a complementary Velcro strip attached to a vertical surface. The researchers believe that they will ultimately be able to replace the Velcro on the drone with a material inspired by gecko feet. This will allow it to stick to any surface, from brick to glass, so it will be able to perch almost anywhere in an urban environment.

The drone is stable both when hovering and perching, but transitioning between the two states is challenging. Custom software calculates the approach speed and angle necessary for the drone to bash its landing gear against a wall and stick to it without sustaining damage. It approaches the wall rotor-first to gain speed and then rotates quickly at about 120 revolutions per minute to land (arxiv.org/abs/2204.02458).

Mao says that the landings are inherently violent because “you just have to use the initial momentum to slam it down” and that this could cause problems in choosing appropriate spots to perch.

“No one’s going to be happy with this sticking to their apartment [window], but I think if we could cordon off special areas, or say ‘in an emergency, you’re allowed to do this’, then it’ll be fine,” he says. ■

Ecology

Global warming and farming may have already hit insects

Carissa Wong



Male great diving beetle (*Dytiscus marginalis*)

temperature rises and high-intensity agriculture, there were 49 per cent fewer insects than in regions where the effects of climate change are minimal and there is little human activity. In the regions worst affected by climate change and farming, there were 27 per cent fewer insect species than in regions little affected by climate change and farming.

The team also discovered that insect numbers and diversity declined more in tropical regions compared with non-tropical regions, probably because the insects in tropical regions are less well adapted to temperature rises (*Nature*, doi.org/hq4b).

“Insects in temperate regions are much closer to their cold limits than their warm limits, whereas in the tropics, places are just getting too hot for them,” says Outhwaite.

On a positive note, the researchers discovered that fewer insects are lost around areas of low-intensity agriculture – even in the face of climate change – if the agricultural land is surrounded by more natural habitat.

“In sites with a lot of natural habitat in the surrounding area, we don’t see as high reductions in biodiversity compared to places with little natural habitat in the surrounding area,” says Outhwaite.

“The study makes an unequivocal case that increasing global temperatures and agriculture are major drivers of insect loss,” says David Wagner at the University of Connecticut. ■

THE combined effects of climate change and agriculture may be responsible for large declines in insect populations around the world, with the worst-hit regions seeing a 49 per cent drop in numbers.

“In areas where we have high-intensity farming, coinciding with high climate change, we see reductions of [nearly] 50 per cent in the abundance of insects compared to places [with untouched] vegetation, where very little climate change has occurred,” says Charlotte Outhwaite at University College London.

The study is the first to measure the effects of both warmer temperatures and agricultural activity on insect biodiversity on a global scale.

Outhwaite and her colleagues analysed data from 264 earlier studies that together tracked insect biodiversity across a total of 6095 sites around the world. The studies covered 17,899 insect species, including beetles, wasps, butterflies and crickets, with data collected between 1992 and 2012.

The team first classified each site into a group depending on whether or not it had been disrupted by human activity, including if it had been used for high-intensity or low-intensity agriculture. They defined sites of high-intensity agriculture as those in which only one crop type was grown, or high levels of pesticide were used.

“Increasing global temperatures and agriculture are major drivers of insect loss”

The researchers calculated the extent of local warming over recent decades by comparing the average temperature at each site – as recorded in the five years before the insect biodiversity count – with a baseline average temperature measured in the region between 1901 and 1930.

They then created a model to assess links between temperature changes and both the number and diversity of insect species.

They found that in regions with the highest

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THE PROBLEM

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Nearly every medical procedure, from cancer treatment and organ transplantation to hip or joint replacement, is dependent on effective antibiotics. Infection is now the second largest cause of death in cancer patients.

The lack of new antibiotics and the growing microbial resistance puts us all at risk. As microbes continue to evolve resistance, we face a growing chance that even a minor cut could become deadly. It's not just a future threat:

1.3 million people (more than the population of Edinburgh and Bristol put together) were killed worldwide by infections that were resistant to antibiotics in 2019.

Antibiotic resistance is the hidden pandemic that is already here.

But we can all make a difference if we act now. We all have a role to play to protect ourselves, friends, family and future generations from drug-resistant infections.

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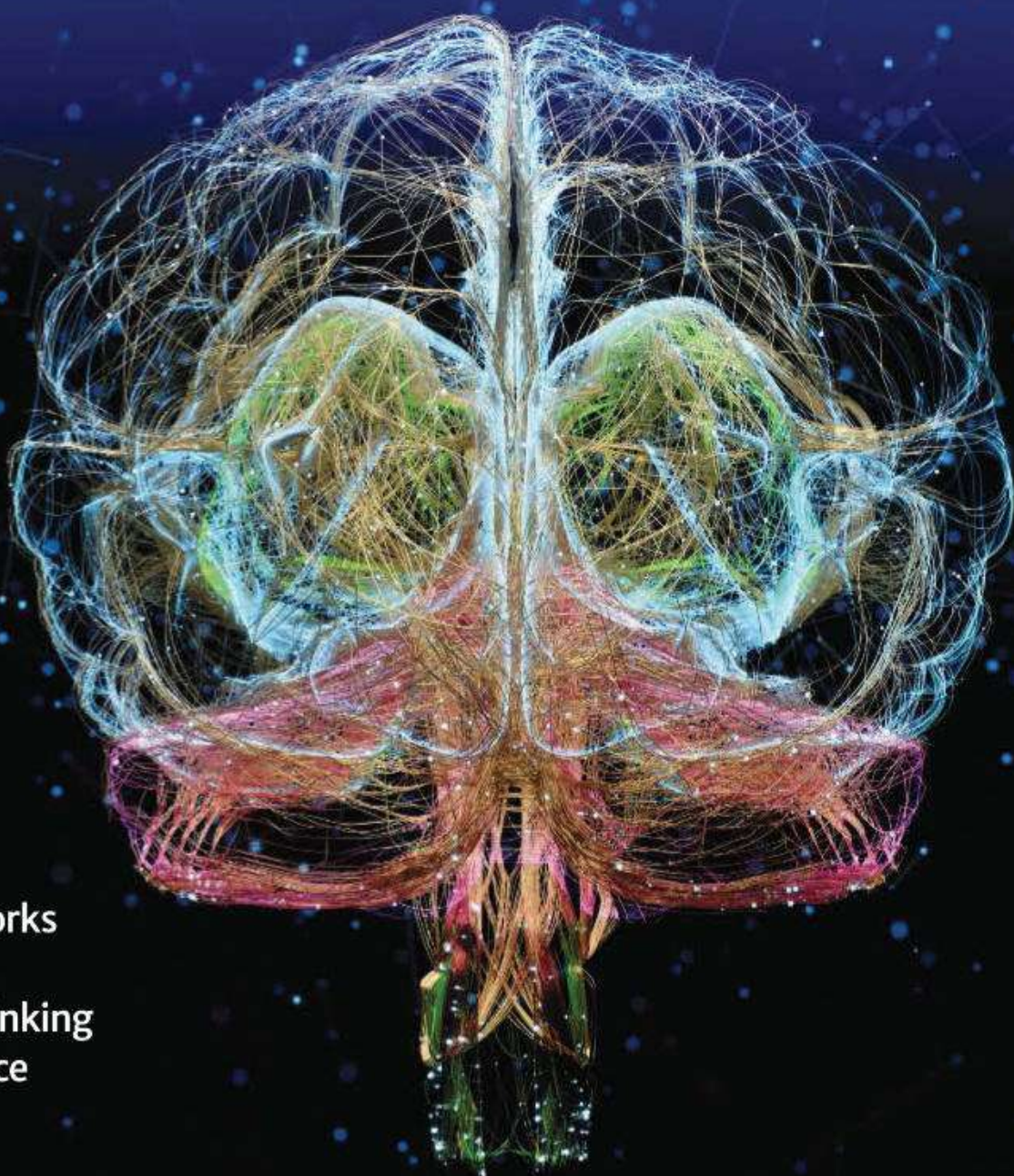
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Space exploration

Planetary scientists call for NASA missions to Uranus and Enceladus

Leah Crane

US PLANETARY scientists have put together a huge report on the state of our knowledge of the solar system and priorities for the next decade of exploration. They recommend two big new missions: a Uranus probe to launch in the early 2030s and a mission to Enceladus, one of Saturn's moons, to take off in the late 2030s or early 2040s.

Once every 10 years, the top research priorities of the entire US planetary science community are identified by the US National Academies of Sciences, Engineering, and Medicine in a process called a decadal survey. This document makes recommendations to the government agencies that fund most of the country's planetary research – primarily NASA and the National Science Foundation – and is often used as a sort of blueprint for the next decade of exploration.

The report laying out the goals for 2022 to 2032, released on 19 April, is titled *Origins, Worlds, and Life*. The process of creating it included 527 white

papers submitted by planetary scientists around the US and nearly two years of discussions among a group of 97 experts.

The highest priority laid out in the new decadal survey is the completion of NASA's Mars Sample Return initiative, which began with the Perseverance rover. The rover has been collecting samples as it explores Mars that it will later leave behind for a planned 2028

**Saturn's icy moon
Enceladus warrants
further investigation**



NASA/JPL/SPACE SCIENCE INSTITUTE

mission to pick up and return to Earth for analysis. Even if the project goes significantly over budget, "NASA should work with the Administration and Congress to secure a budget augmentation to ensure the success of this strategic mission", the report says.

It also recommends two major new missions. The first is the Uranus Orbiter and Probe (UOP), which would ideally launch in 2031 or 2032. The last – and only – time we visited Uranus was with the Voyager 2 probe in 1986, and the planet's inner

workings remain mysterious.

UOP's orbiter would circle Uranus for years, while the probe would sink into the atmosphere to measure its composition, temperature and circulation. "This would be the first ever mission focused on one of the ice giants, which is particularly important now that we think ice giants might be the most common type of planet in the universe," says Robin Canup at the Southwest Research Institute in Colorado, one of the report's chairs.

The second of these big recommended missions is the Enceladus Orbilander, in which a single spacecraft would be both an orbiter and a lander. It would orbit the icy moon for 1.5 years and collect samples from the plumes of liquid water that blast from Enceladus's buried ocean, then land, take more samples and analyse them for signs of life.

There were also several smaller recommended missions, including a lunar rover called Endurance-A to collect samples from the moon's south pole for astronauts to bring back to Earth. ■

Animal behaviour

Dolphins that are hand-fed by tourists become less social

FREE-ROAMING dolphins that are fed by hand become less socially involved with their peers. As a result, their calves may grow up lacking vital social skills – which could explain, at least in part, why they are twice as likely to die before reaching adulthood as wild calves generally.

Some tourist centres train Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) to approach

beachside public sighting areas or boats by hand-feeding them small amounts of fish every day. Because hand-fed males aggressively attack each other over the food – putting themselves and nearby humans in danger – tourist centres focus their hand-feeding only on female dolphins, says Valeria Senigaglia at Murdoch University in Perth, Australia.

But recent studies have shown that only 38 per cent of the calves of hand-fed wild dolphins survive to 3 years of age, which is much lower than the average 77 per cent survival rate for wild calves

in general. To better understand why, Senigaglia and her colleagues evaluated the social behaviour of dolphins along the Bunbury coast in Western Australia.

In particular, they observed the individual behaviour and movement of 35 dolphins, including 13 that had been hand-fed. Using a small boat, they regularly followed each dolphin for periods lasting from 20 minutes to 3 hours for two years

"You can be solitary in a room full of people, and it's the same thing for dolphins"

in a row, for a total of 180 hours.

They found that hand-fed dolphins swam in relatively large groups, but more readily broke away from them to join different ones. In general, they created weaker ties with other group members (*Animal Behaviour*, doi.org/hq38).

"You can be solitary in a room full of people, and it's the same thing for dolphins," says Senigaglia.

Calves of hand-fed females were also less social with other dolphins, which might be a factor in their survival. ■

Christa Lesté-Lasserre

Palaeontology

Fossil skull hints feathers date back 250 million years

PTEROSAURS – flying reptiles that thrived millions of years ago – may have had multicoloured feathers. We know that some dinosaurs, which are cousins of pterosaurs, had feathers like this, but the discovery of feathers with different colours on a pterosaur indicates that feathers may have come about 100 million years earlier than thought, even before flying vertebrates.

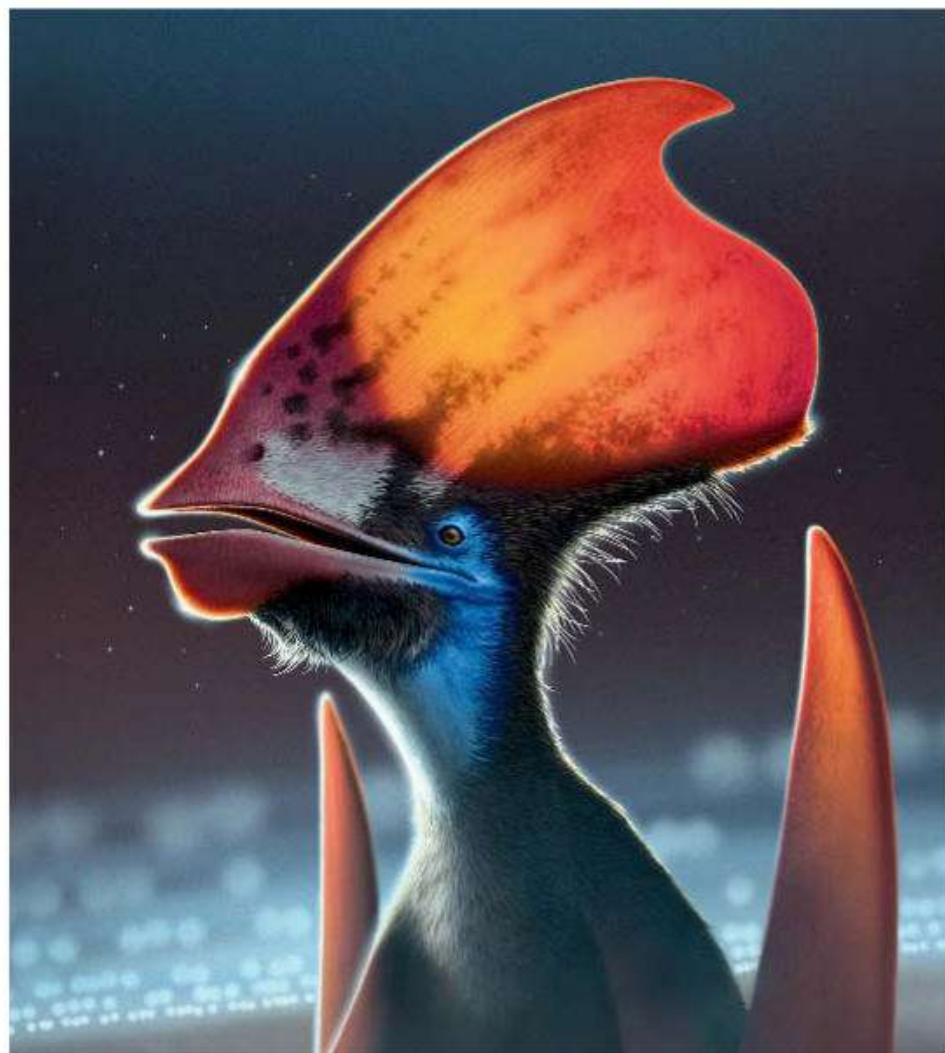
Maria McNamara at University College Cork in Ireland and her team found preserved feathers on a fossilised pterosaur skull. This species, *Tupandactylus imperator*, had crests on their heads (illustrated left); the feathers on this skull were found on either side of the crest.

They found two types of feathers: whisker-like monofilaments and more complex branching feathers. Each type had different sorts of

melanosomes, components that make and store the pigment melanin. By comparing these melanosomes with those in modern feathered animals, the team worked out that the bristly monofilaments were probably black or dark brown, while the fluffier branched feathers were probably a lighter shade of brown (*Nature*, doi.org/hq7c).

Because both pterosaurs and some dinosaurs had multicoloured feathers, the feathers were probably passed down from a common ancestor in the early Triassic period, around 250 million years ago, says McNamara.

“[This finding demonstrates that] feathers arose long before flight, and so must have been for insulation or signalling,” says Michael Benton at the University of Bristol, UK. Leah Crane



BOB NICHOLLS

Medicine

CRISPR used to treat brain cancer in mice

A TINY capsule that delivers the gene-editing tool CRISPR to the brain has been used to treat glioblastoma, one of the most aggressive forms of brain cancer, in mice. This approach halted tumour growth and extended lifespan in the animals.

CRISPR is a tool for adding, removing or altering genetic material inside cells. It is accurate and cheap compared with other gene-editing methods, but has been tricky to use in the brain.

Most methods for targeting the brain involve either direct injection into brain tissue or inserting CRISPR into non-disease-causing viruses and then injecting these into the bloodstream. Both methods have big drawbacks, including potential injury to brain tissue or, in the case of viruses, difficulty in pinpointing delivery, meaning an increased risk of

serious side effects such as unintended genetic mutations.

By packaging CRISPR in specially designed nanocapsules – tiny non-toxic polymer bubbles – researchers have been able to address these problems elsewhere in the body, but not in the brain.

Now, Yan Zou at the Henan-Macquarie University Joint Center for Biomedical Innovation in China and her colleagues have designed a new nanocapsule that can deliver CRISPR therapy via the blood to brain tumours in mice.

They used CRISPR to target a gene called *PLK1*, which regulates development of new cells, and in glioblastoma essentially goes into overdrive. In the study, tumour growth stalled in mice that were given a single injection. These animals also had a median survival time of 68 days, compared with 24 days or less in control groups. What's more, the treatment caused negligible unwanted mutations (*Science Advances*, doi.org/hq7j).

Grace Wade

Technology

Leap forward for printing objects

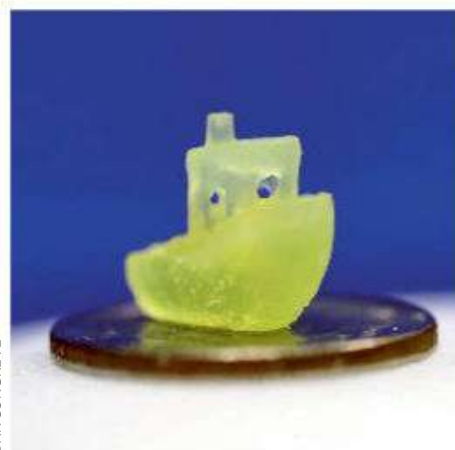
A 3D printer that uses lasers to build up an object in any order, rather than layer by layer, could produce more advanced designs than is currently possible.

Existing 3D printers work by depositing layers of plastic from a nozzle or by curing layers of resin with UV light. In both cases, objects are built up one layer at a time, meaning that overhanging parts of a structure must be

propped up by temporary supports until printing is complete. These supports must then be removed manually.

To get around this, Dan Congreve at Stanford University in California and his team created a system that involves focusing a red laser at a particular point in a pool of resin. The resin contains particles that convert red light into blue once the light hits a certain energy threshold, which only occurs at the point where the red laser is precisely focused. When this happens, the surrounding resin reacts to the blue light, hardening (*Nature*, doi.org/hq7g).

Congreve says that one or more lasers could rotate around a pool of resin and print an object in any order as it stays suspended in the thick material. The end product, such as a model boat (pictured), is removed from any leftover liquid and rinsed. Overhanging areas and delicate designs that would be tricky with existing 3D printers can be easily made. Matthew Sparkes



DAN CONGREGUE

Really brief



SHUTTERSTOCK/MARCINW111

Stressful times as dogs await a home

Dogs housed in a shelter became stressed while there. After six weeks, their hair contained 31 per cent more cortisol, a stress hormone – although the levels dropped again after the pets had been adopted. The study might lead to a new tool for monitoring dog welfare (*Scientific Reports*, doi.org/hq4s).

Inexplicable blasts seen on dead stars

A new type of explosion has been discovered on white dwarfs, a type of dead star. These “micronovae” are about a million times less bright than classical stellar explosions. They were found using NASA’s Transiting Exoplanet Survey Satellite, but why they occur isn’t clear (*Nature*, doi.org/hq4v).

Safety signs may cause car crashes

Electronic road signs used to highlight driving fatality rates may actually cause crashes, an analysis of data from Texas suggests. When signs showed crash figures, accident rates on the next 10 kilometres of road rose by 4.5 per cent – perhaps because drivers were distracted by the message (*Science*, doi.org/hq4w).

Archaeology

Campfire rock art could look animated

STONE Age people may have huddled around fires at night to watch simple animations created as firelight danced across artwork etched on flat rocks.

Recently, some archaeologists have speculated that the burning torches required to view Stone Age art deep in caves turned them into rudimentary animations as the light from the flames highlighted first one and then another image.

Now, Andrew Needham at the

University of York, UK, and his team have found evidence that such effects weren’t confined to deep caves. Instead, art etched onto flat stones called plaquettes and placed near hearths around which people gathered at night may also have looked animated.

The art they examined was found at a rock shelter in France and was probably created between about 16,000 and 13,500 years ago.

The researchers point out that most of the plaquettes have one feature in common: evidence of exposure to heat. Because other ancient artefacts from the rock

shelter don’t show this, they argue that the plaquettes were routinely placed near campfires.

The researchers wondered what effect flickering light from the flames might have had on the artwork. To explore this, they produced 3D computer models of the plaquettes and used virtual reality to simulate dim light dancing over their surfaces. This revealed that the light can draw attention to first one and then another animal engraved on the plaquette, giving an impression of movement (*PLoS One*, doi.org/hq7k). **Colin Barras**

Solar system



NASA/JPL/ASU

Mystery of weird ridges on Europa may have been solved

JUPITER’S moon Europa is covered in strange pairs of parallel ridges. Now, researchers have found a similar feature in Greenland and used it to unravel how such ridges form.

Europa has parallel pairs of ridges hundreds of kilometres long and hundreds of metres high all over its surface, but it has been hard to explain how they came about because we have no direct data on what is going on under the surface.

Riley Culberg at Stanford University in California spotted a similar pair of ridges in satellite images of the Greenland ice sheet. He and his colleagues analysed how these formed and found that it was

due to pockets of liquid water within the ice sheet. When some of that water refreezes, it expands, creating cracks in the ground and pressurising the remaining water, which pushes upwards on either side of the refrozen section. That upwelling causes the parallel ridges to form (*Nature Communications*, doi.org/hq7d).

If the same process creates the ridges on Europa, that implies there is shallow water within its 20 to 30-kilometre-thick shell of ice – something that has been suggested before, but never in connection with the ridges. This might be good for the prospect of life on this moon. **LC**

Chemistry

Synthetic nerve cells created in the lab

ARTIFICIAL nerve cells produced from biocompatible materials have been made for the first time. The innovation may one day be used in synthetic tissues to repair organs like the heart or the eyes.

Hagan Bayley at the University of Oxford and his team devised a synthetic material that can act in a similar way to a human neuron. Made from hydrogel, the artificial neurons are about 0.7 millimetres across – some 700 times wider than a human neuron.

When a light is shone on the neuron, it activates proteins that pump hydrogen ions into the artificial cell. These ions move through the neuron, carrying an electrical signal. When this signal reaches the tip of the neuron, the neurotransmitter adenosine triphosphate is produced (*Nature Chemistry*, doi.org/hq7v).

However, the artificial neurons still have a long way to go. Unlike real neurons, they don’t recycle and create new neurotransmitters in the synthetic system. They therefore only work for a few hours, says Bayley.

He hopes to eventually use the synthetic cells to deliver a range of drugs simultaneously to treat wounds more rapidly and more precisely. **Jason Arunn Murugesu**

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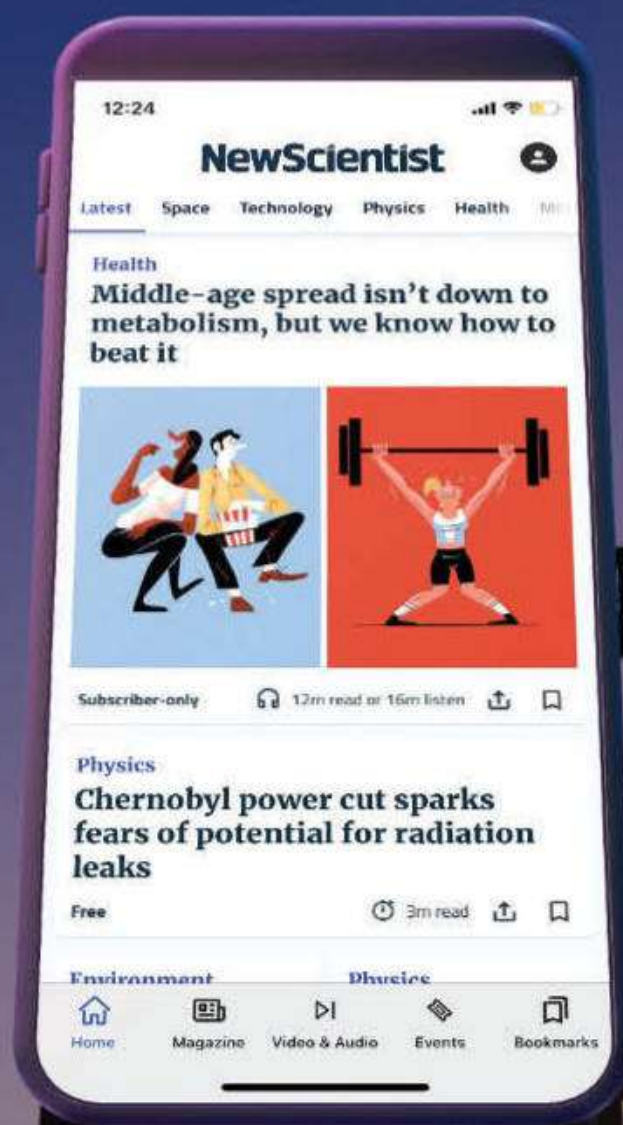
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Culture columnist

Jacob Aron battles a robot *T. rex* in a post-apocalyptic game **p36**

Comment

Say it loud and clear

The public needs to hear about science from the people who do it, without government spin getting in the way, argues **Fiona Fox**

WHEN the BSE crisis deepened in the 1990s, John Gummer, then minister of agriculture, invited the press to photograph him trying to feed a beefburger to his 4-year-old daughter, claiming that scientists had advised it was perfectly safe to eat the meat. In fact, they had said there was a low but “theoretical” risk of getting BSE, or bovine spongiform encephalopathy, a neurological disease of cattle.

But this more nuanced take didn’t reach the UK public at the time because the scientists giving it were hidden from view, just as they were during later crises, such as the 2010 Eyjafjallajökull volcanic eruption in Iceland or the 2011 Fukushima nuclear disaster in Japan. Gummer was glossing over the scientific uncertainties to deliver a clear “message” that was convenient for the UK beef trade. As a result, the public were misled and trust in science suffered.

To avoid this in the future, there needs to be a clearer separation between science communication and government communication, so the public can hear science directly from those doing it.

One of the few positives in the pandemic was seeing so many leading scientists on our TV screens. While the UK prime minister Boris Johnson used the Downing Street press conferences to deliver key policy decisions and “messaging”, he was flanked by chief scientific advisor Patrick Vallance and chief medical officer



MICHELLE D'URBANO

Chris Whitty who summarised new data and answered media and public questions on the science. This was science communication at its best when most needed and it was a hit with the public. Trust in scientists topped 90 per cent at times as the pandemic unfolded.

Despite this, when the government spin machine got too involved, things got less sciency and more political. As head of the Science Media Centre, an independent organisation promoting scientific literacy in reporting, I lost count of the times I lined up briefings on pandemic-related findings with a panel of

great researchers only to turn on a news broadcast and hear ministers announce those findings early. The result: coverage by political journalists with little science but often with government spin.

That wasn’t the only problem during the pandemic. Ministers got a rebuke from regulators for announcing major developments that would impact us all without making scientific data they relied on available for others to assess.

Even more worryingly, in a revealing essay about behind-the-scenes government strategy, Lee Cain, Johnson’s former director of communications, called for a

more centralised structure to ensure clear single “messaging” on issues like covid-19. That comms officers are desperate to control the “narrative” in a national crisis is nothing new. But such calls only bolster the case for ensuring science is presented independent of government announcements.

Luckily, we have a precedent. After years of complaints about the way official UK statistics on everything from crime to unemployment were being spun by politicians, campaigners finally convinced the government to address this in the 2017 Code of Practice for Statistics. The result is that figures about our national life are first published as raw data by organisations like the Office for National Statistics. Politicians can comment on these figures like the rest of us, but taking the initial communication away from ministers means we see the numbers without political spin.

Applying this idea more widely would be good for all of us. Critically, the system would also establish the principle that science needs to be impartial and free from politicisation.

The loss of control might be painful for government, but the benefits in terms of public trust in science would be worth it. As the pandemic has shown, that really can be a matter of life and death. ■



Fiona Fox is head of the Science Media Centre and author of *Beyond the Hype*

This changes everything

The remote future Working from home might sound enticing, but a two-tier system is emerging in which it is valued less by employers. This division will only grow, warns **Annalee Newitz**



Annalee Newitz is a science journalist and author. Their latest novel is *The Future of Another Timeline* and they are the co-host of the Hugo-nominated podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is techsploitation.com

Annalee's week

What I'm reading

"All-Electric" Narratives by Rachele Dini. All about homemakers who paid for expensive appliances to do unpaid labour!

What I'm watching

Abbott Elementary, a charming sitcom about teachers trying to get by at a US school with no funding.

What I'm working on

A story set in the early universe, when stars were just starting to form.

This column appears monthly. Up next week: Beronda L. Montgomery

HERE in the US, stay-at-home orders evaporated long ago, and many companies are demanding that workers return to the office. Yet we are still being inundated with news about people who are lucky enough to continue working remotely. Books, articles and software packages promise to help us navigate a new era of "hybrid offices". It sounds enticing. No more commutes and foul office smells! But the future of working from home may be a lot darker than anyone realises.

I am not worried about what is going to happen to remote working over the next year or two. Many white-collar workers and techies have been doing it for years now – I haven't had a job that requires me to go into the office for nearly 15 years. In the noughties, I communicated with colleagues via group chat apps and email lists; in the teens, we used Campfire and Slack. Now we use Zoom and other video chat systems. The only thing that has changed since the pandemic is that my outlier experience has become the norm for certain groups of workers.

Twitter, Spotify, Reddit, Square and Slack have all announced that they will allow employees to work from home permanently. But for all their talk of boosting productivity and creating a better work-life balance, the move to hybrid work can come with a cost – literally. Facebook and Twitter will pay less for certain work-at-home staff, and Google could slash their salaries by up to 25 per cent.

Along with such pay cuts comes a new generation of home surveillance software, which tracks employees' online activities, while sometimes using live video feeds to measure how long they sit at their desks. And

you can forget about organising a union in a virtual workplace where every private message you send can be read by your boss.

So far, these companies haven't received much pushback, because most employees think of remote working as a perk. In one survey, nearly half of workers said they would accept a pay cut if they never had to go into the office again. Tayo Bero has pointed out in *The Guardian* that this isn't just because people hate to commute: "For Black women, staying at home has meant a reprieve from some of the microaggressions that they would typically face in

"Even if remote workers pop up on Zoom, their work will be consistently devalued as time goes on"

an in-person work environment."

Still, we are witnessing the emergence of a two-tiered system, where working from home is valued less by employers. I suspect that the class divisions here will only grow more stark as the years go by, especially when you consider that a great deal of remote working is done by people who are picking up micro-jobs from TaskRabbit, Fiverr and dozens of other sites where you can do 5-minute jobs for pennies.

These gigs can be horrifying: a lot of content moderation is done by home workers who have to evaluate reams of violent videos and hateful comments. Frequently, these micro-tasks take longer than the time allotted. If you spend 10 minutes doing a supposedly 5-minute task, you won't get paid extra – and your ranking will sink, making it harder to get another micro-job.

How long before Twitter or Spotify start to carve up their cosy work-at-home jobs into micro-tasks for gig workers? And consider what else may soon be expected of home workers. In 20 years, employers may want staff to come with their own computer purpose-built for work, along with a virtual reality rig, 3D printer and perhaps even a drone set-up for delivering prototypes.

But, you might protest, that would never happen to a fancy front-end designer or architect. Their work will always be valuable, even if they get paid less and have to buy more equipment than their in-office colleagues. Will it, though?

There is a persistent bias against work done in the home. Domestic tasks such as cleaning and childcare have been unpaid for centuries. As Rachele Dini at the University of Roehampton, UK, noted recently on the BBC's *Arts & Ideas* programme, it has been nearly impossible to gain public support for the idea that homemakers should be compensated for their work. Even when people do it for money, domestic work is consistently undervalued.

This is partly the result of prejudice: women and immigrants tend to do most domestic work. But it is also a function of what cognitive scientists call "distance bias", in which managers place more value on work done by people in closer proximity to them. Remote workers are out of sight, out of mind. Even if they pop up on Zoom, their work will be consistently devalued as time goes on, just as housework has been.

I am not saying that we should embrace going into an office every day. But we should be wary when companies use our desire to work from home as a trick to get us to accept second-class status. ■



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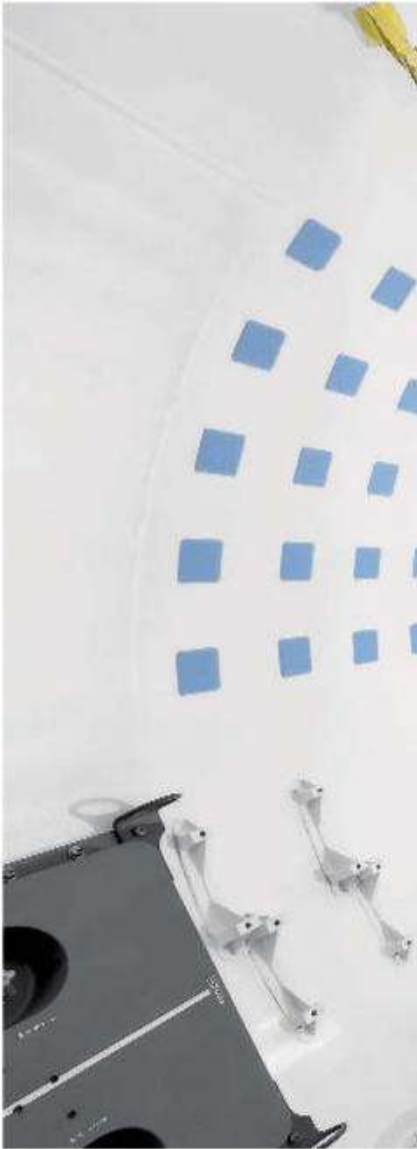
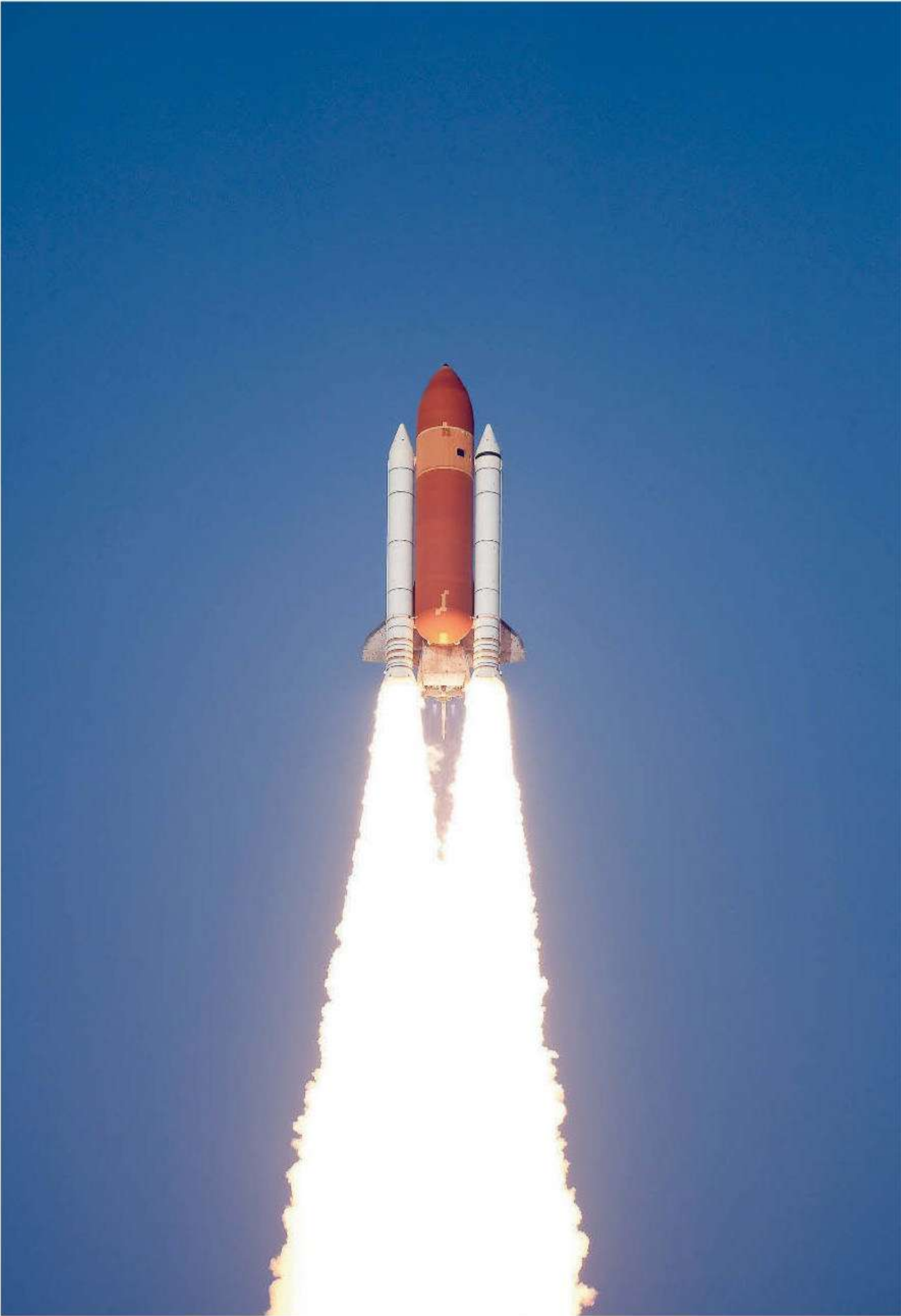
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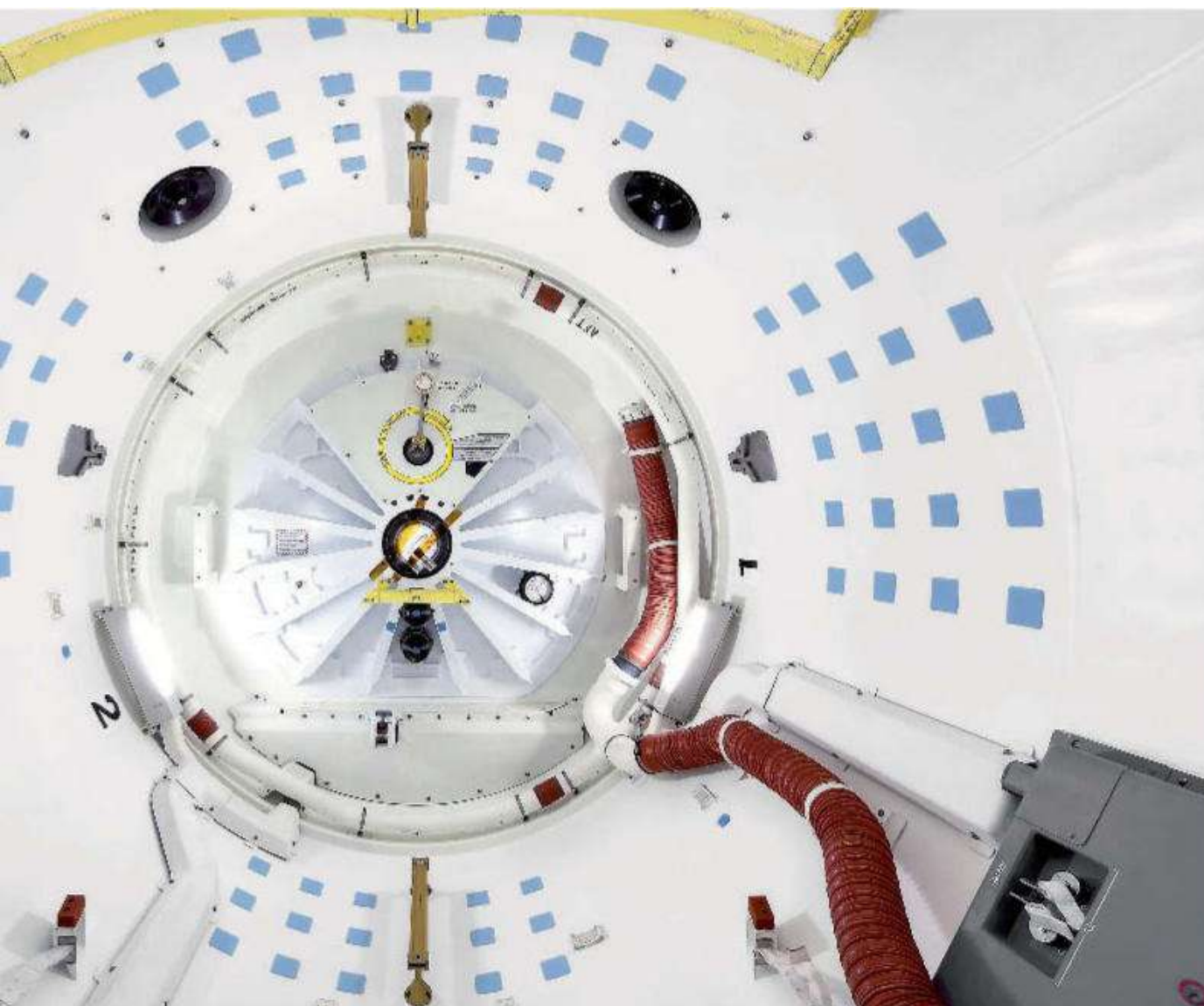
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Inner space



Photographer **Roland Miller**

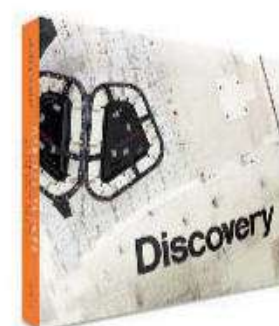
THESE intimate and detailed photos of space shuttles and the International Space Station (ISS) offer a privileged peek inside one of the biggest programmes in space flight.

They come from the new book *Orbital Planes: A personal vision of the space shuttle* by photographer Roland Miller (see cover below), published by Damiani Editore. It depicts spacecraft from NASA's space shuttle programme, which flew 135 crewed missions from 1981 to 2011 using five spacecraft: Columbia, Challenger, Discovery, Atlantis and Endeavour.

The space shuttles were designed to provide backup for space travel and maintenance, including building the ISS, transporting cargo and launching, recovering and repairing satellites.

Miller started work on *Orbital Planes* as the craft were being decommissioned. The image on the far left shows the launch of the STS-133 mission in February 2011, in which Discovery docked with the ISS. The trio of smaller images show (clockwise from the top): the airlock and hatch of the ISS as seen from Discovery, the ceramic tiles lining the exterior of Atlantis (to protect the shuttle from the heat of re-entry), and the commander's console on board Endeavour. ■

Gege Li



Editor's pick

Trying to pin down a planet is pointless

2 April, p 16

From Sam Edge,

Ringwood, Hampshire, UK

The waste of effort represented by the "struggle to define a planet" is beyond me. I could try to argue that there is an absolute qualitative difference between big and very big that everyone on Earth should follow, based on my arbitrary definition of the line between the two. I don't think anyone would pay much attention – at least I hope not.

The brouhaha when Pluto was "demoted" to dwarf planet status was ridiculous. It is what it is, based on its measurable properties. It bears similarities to other objects and differences from them too. Let it go, for heaven's sake.

By the way, I have to take issue with the assertion that the International Astronomical Union's 2006 definition of planet is "final". I suspect more exoplanet data makes it likely that this will change.

Poverty may scupper energy efficiency hopes

2 April, p 20

From Keith Baker, research fellow in fuel poverty and energy policy, Glasgow Caledonian University, UK

Adam Vaughan's article "Time to green your home" is a welcome contribution, but it omits a proverbial elephant in the living room. In fuel poverty circles, we often talk about the "heat or eat" dilemma, but in the UK we are rapidly heading towards the point where many people will be struggling to pay mortgages or rent. If this happens, then fuel poverty effectively converges with general poverty – very bad news.

We know that the more stress people are under, the less they are able to function, and so those who are simply struggling to stay afloat aren't going to engage with support for improving the energy efficiency of homes, particularly

if that support is delivered online or over the phone.

This is the ultimate fallacy of the belief that treating fuel poverty primarily as a problem of energy inefficiency means it can be solved primarily by technical solutions. My work with colleagues shows we need to switch to a holistic person-centric approach that treats households, not just homes.

From Robert East, London, UK

Vaughan mentions the high cost of insulating solid walls in older homes. What is needed are plastic vacuum insulation panels. These exist, but are costly. It should be possible to mass produce them cheaply in a form that could easily be mounted on an exterior wall.

To overcome this crisis, science must be challenged

9 April, p 45

From Rex Last,

New Alyth, Perthshire, UK

The only way for science to overcome its problems with replication is for the "scientific model", which is overly reductionist and resistant to change, to be more convincingly challenged and fearlessly exposed.

Biology needs many points of view to prosper

Letters, 9 April

From Nick Burke,

Portland, Oregon, US

In his response to the discussion of Victorian distortions of biology, Jonathan Wallace questions the idea that a feminist input is needed, on the grounds it may lead to wrong conclusions. On the contrary, I would say a larger number of perspectives can produce a more complete picture.

With more views available to

critical thinkers, and more diverse observations, ideology is less likely to slip through.

Such a shame that clean coal power never got going

26 March, p 18

From Pamela Ross,

Findochty, Moray, UK

The energy crisis takes me back to the time I campaigned for the UK coal industry on behalf of fellow trade union members. Part of that was to ensure security of supply as part of a diverse energy mix.

I spent years lobbying on behalf of clean coal – coal-fired power plants using carbon capture and sequestration. Governments said these were part of their plans for the future. They even expressed intentions of supporting suitable projects. Sadly, none happened.

Surely this takes us back to a 3D universe

2 April, p 38

From Tim Jackson,

Haslingden, Lancashire, UK

I must raise a point regarding "Consciousness in the cosmos". Even in the block universe, to say that "past, present and future all exist at once" is still an oxymoron. "At once" implies being at the same point on the time axis, suggesting this axis has zero length. That reduces the four-dimensional block universe to a three-dimensional space-time.

Could we use carbon dating to find Martian life?

19 March, p 14

From Ed Prior,

Poquoson, Virginia, US

Noting the "Organic mineral bonanza on Mars" found by NASA's Curiosity rover in Gale

crater makes me wonder if there have been any attempts to determine concentrations of the radioactive isotope carbon-14.

If any microbes on Mars are like Earth's, they will absorb and assimilate carbon, including carbon-14, during their lifetime, but at death the content of this in cells begins decreasing at a known rate. We use this fact on Earth to "carbon date" ancient artefacts and bones. Is it possible the presence of dead or live microbes in the Martian surface could be revealed by a changing fraction of carbon-14 in organic Martian soil?

Just can't put a stake in heart of vampire power

2 April, p 30

From Hillary Shaw,

Newport, Shropshire, UK

The problem of "vampire power" use by devices on standby may be hard to eradicate. In our house, the internet router, telephones, radio clock, boiler, burglar alarm and thermostat stay on. Sometimes, the TV is on standby so it can record. Turning these off, some of which would need resetting each morning, could be time-consuming or counterproductive.

This does mean higher-earning households may trade power costs for time, which is inequitable.

Five reasons why nuclear power just doesn't add up

Letters, 5 March

From Paul Whiteley,

Bittaford, Devon, UK

There is more to the nuclear power debate than economic circularity advantages raised by earlier letters. Energy production should be clean, safe, renewable, secure and as cheap as possible.

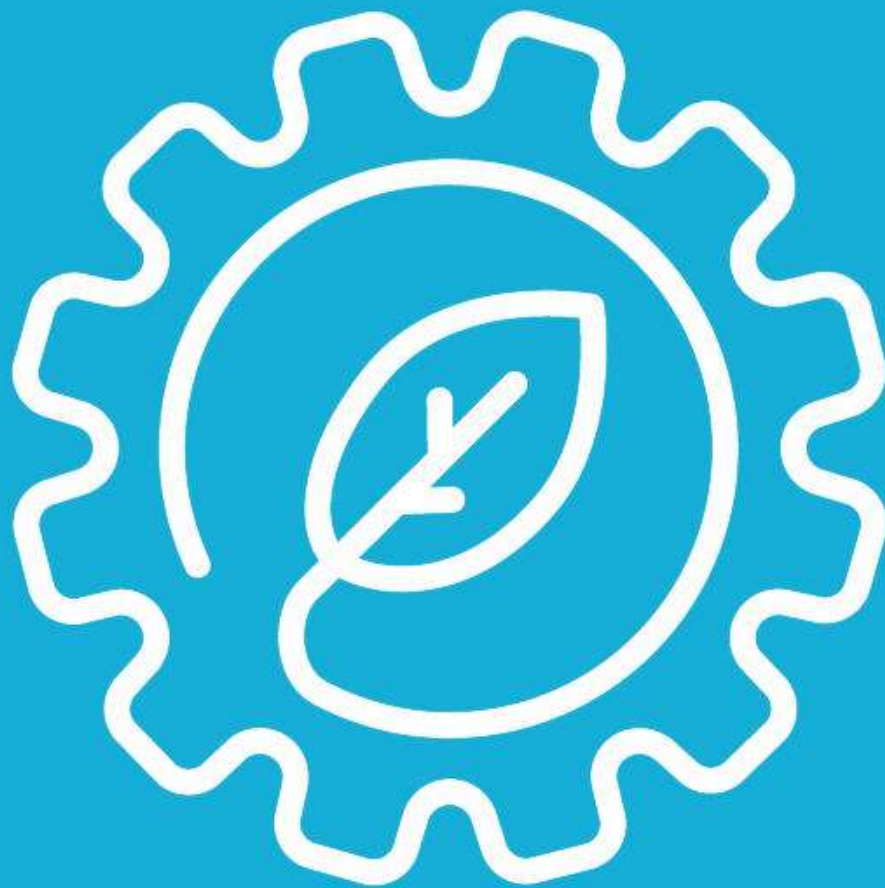
Nuclear isn't clean, given its waste problems. It isn't safe, as evidenced by major accidents, nor is it secure – plants are vulnerable to attack. It also isn't renewable: uranium is a finite resource. No one would call it cheap. Why are we still talking about it? ■



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How physics shaped the world

This account of 12 significant discoveries in physics is detailed yet pacy – and has a cheering takeaway for the future, says **Elle Hunt**



Book

The Matter of Everything

Suzie Sheehy

Bloomsbury

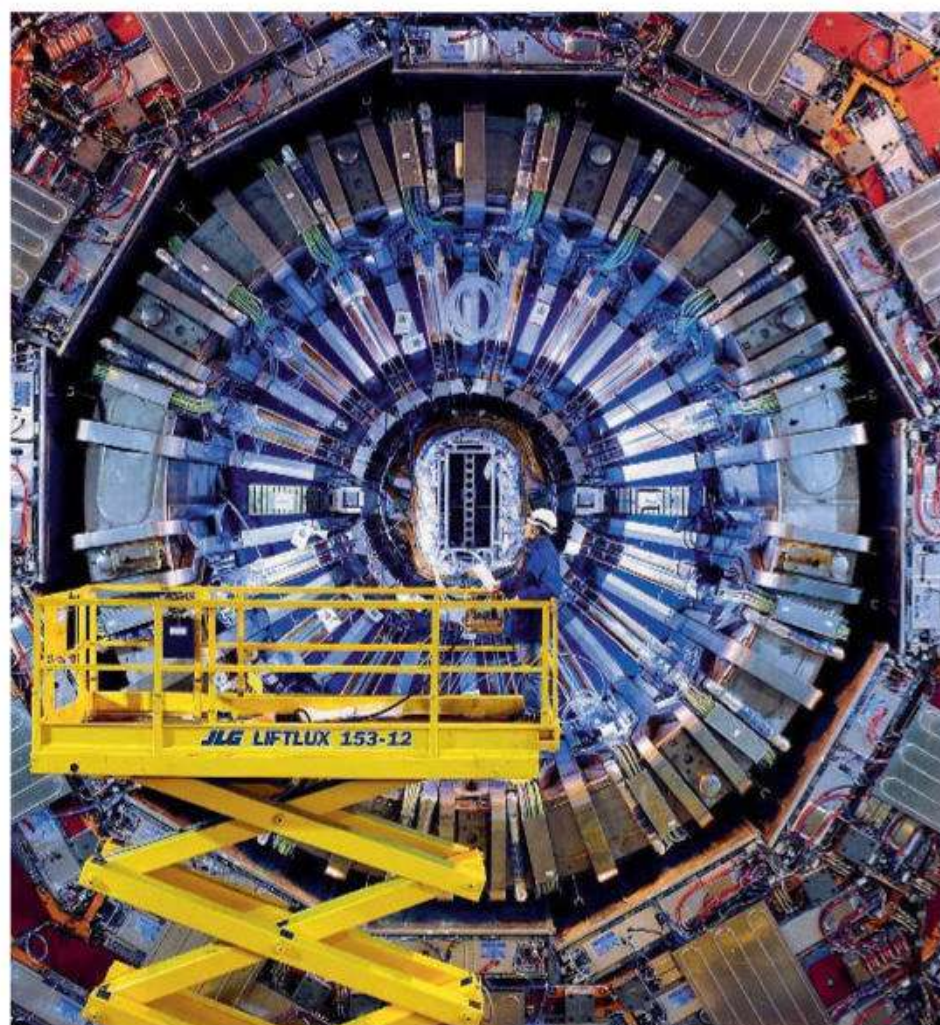
IN 1930, Austrian physicist Wolfgang Pauli set out to solve a mystery. The variability of energy values for beta particles, defying the basic scientific principles of conservation of energy and momentum, had been confounding physicists since the turn of the century.

Pauli – a physicist so rigorous in his approach that he had been called “the scourge of God” – seemed well-placed to address it. And yet, when he put his mind to finding a theoretical solution for the problem of beta decay, Pauli created only further ambiguity.

He proposed the existence of an entirely new, chargeless and near-massless particle that would allow for energy and momentum to be conserved, but would be almost impossible to find. “I have done a terrible thing,” he wrote. “I have postulated a particle that cannot be detected.”

Pauli, a pioneer of quantum physics, is one of many names to cross the pages of *The Matter of Everything*, Suzie Sheehy’s lively account of “experiments that changed our world”. Through 12 significant discoveries over the course of the 20th century, Sheehy shows how physics transformed the world and our understanding of it – in many cases, as a direct result of the curiosity and dedication of individuals.

Sheehy is an experimental physicist in the field of accelerator physics, based at the University of Oxford and the University of Melbourne, Australia. Her own expertise makes *The Matter of Everything* a more technical



The Large Hadron Collider at CERN near Geneva, Switzerland

world war showed what was possible – for good and evil. Sheehy describes how the development of the bombs that destroyed Hiroshima and Nagasaki awakened a social conscience in the field, paving the way to the international cooperation we see today, such as on the Large Hadron Collider.

United behind a common goal, and with cross-government support, answers that had never before seemed possible suddenly appeared within grasp. To Sheehy, this is evidence of the potential for physics to overcome the challenges that face science and society now – from the nature of dark matter to tackling the climate crisis.

At the start of the 20th century, she points out, it was said that we knew everything there was to know about the universe; by the end of the century, the world had changed beyond recognition.

The terrible particles Pauli proposed – which he called neutrons, but we now know as neutrinos – were finally confirmed in 1956. His response was quietly triumphant: “Everything comes to him who knows how to wait.”

A sweeping but detailed and pacy account of 100 years of scientific advancement, *The Matter of Everything* has a cheering takeaway. What such leaps lie ahead? What questions seem intractable now that we won’t give a thought to in the future?

Sheehy mounts the case that – with persistence, curiosity and collaboration – we may yet overcome challenges that now seem impossible. ■

Elle Hunt is a freelance writer based in Norfolk, UK

book than the framing of 12 experiments might suggest, and certainly more so than the average popular science title, but it is nonetheless accessible to the lay reader and vividly described.

From experiments with cathode rays in a German lab in 1895, leading to the detection of X-rays and to the discovery of the first subatomic particle, to the confirmation of the Higgs boson in 2012, *The Matter of Everything* is an opportunity to learn not just about individual success stories, but the nature of physics itself.

Sheehy does well to set out the questions that these scientists wanted to answer and what lay at stake with their discoveries, on the macro level as well as the micro one, showing how physics not only helped us to understand the world, but shaped it. These early “firsts” came from small-scale

experiments, with researchers operating their own equipment and even building it from scratch.

The Matter of Everything also highlights those whose contributions might have historically been overlooked,

“Sheehy does well to set out what lay at stake with these discoveries, on the macro level as well as the micro one”

such as Lise Meitner, dubbed the “German Marie Curie” by Albert Einstein. Her work on nuclear fission went unacknowledged for some 50 years after her colleague Otto Hahn was solely awarded the Nobel prize in 1944.

The commitment and collaboration of physicists and engineers through the second

Impossible murders

Elisabeth Moss is after a killer who is defying all known laws of reality in this unsettling sci-fi thriller, finds **Bethan Ackerley**



TV
Shining Girls
Silka Luisa
Apple TV+

CAN a bee live without its wings? And what does it mean to survive against all odds? It is unlikely that the sadistic serial killer in *Shining Girls*, a new sci-fi thriller from Apple TV+, had considered these questions before mutilating a young girl's pet bee in the series' opening scene. What is clear, though, is that he sees the women he attacks as broken-winged, robbed of their perfection – and that this misconception will be his downfall.

Shining Girls stars Elisabeth Moss as Kirby Mazrachi, a filing clerk at a Chicago newspaper in 1992 who is still recovering from a horrific assault six years earlier. Her assailant was never caught, but when the body of a young woman is found with similar injuries, Kirby enlists strung-out reporter Dan Velazquez (Wagner Moura) to help her track down the murderer.

Filing clerk Kirby (Elisabeth Moss) finds her sense of reality starting to shift as she looks for a killer



Their investigation is complicated by Kirby's ever-shifting sense of reality: first, small things change, like whether she owns a cat or a dog. Then, in the blink of an eye, she finds she has been married for years and her rock-star mother is a born-again Christian.

As the bodies stack up, Kirby and Dan learn that the timeline of the killings can't possibly make sense. While investigating the murder of a woman in 1972, they discover she had a locker key from 1992 in her possession. The more they uncover about the connections between the victims, the more impossible the killings seem.

Fans of *The Shining Girls*, Lauren Beukes's 2013 novel on which the show is based, should note that the series is considerably different. It largely eschews the grisliness of its source material, which devoted much of its narrative to the killer's perspective. Instead, it has been transformed into a cerebral, mind-bending puzzle, with the murderer (Jamie Bell) and his methods left a cipher. All we know is that he is a clean-cut man with an almost omnipotent level of control over his victims – the "shining girls" – to the point where he seems to defy all known laws of reality.

For the most part, this restraint is wise: TV is hardly in need of more gruesome depictions of violence against women, after all. But losing the jagged mastery of the novel draws attention to the series' deficiencies. The violence in the book was extreme but never gratuitous, designed to paint a picture of the noirish world Kirby inhabits. By contrast, aside from a few vivid montages, *Shining Girls* is often lacking in visual flair. And while many details of the other women's murders have been expunged, so have the stories of their lives and dreams – only Kirby and a couple of other "shining girls" are fleshed out.

What can't be faulted, though, are the performances of the show's three leads. As Kirby, Moss really does shine. She is fragile and furious by turns, taking the increasingly large shifts in her reality in her stride. Moura, too, is hugely charismatic, making Dan's aptitude for reporting clear even as his dependency on alcohol worsens.

And despite the dearth of information about his character, the killer avoids feeling one-note thanks to Bell. *Shining Girls* is careful to show the smaller-scale ways in which he harasses and demeans his victims before killing them. In this sense, he is a garden-variety misogynist, and Bell skilfully conveys how these small seeds could have grown and put him on a path to murder.

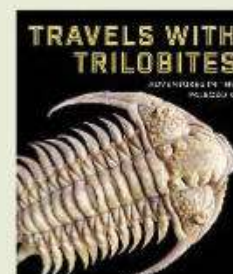
The first four episodes of *Shining Girls* set up a satisfying mystery, filled with unsettling twists that pull at the edges of reality. But it is the themes of trauma and renewal – at once more mundane and more remarkable than any sci-fi conceit could hope to be – that make the series worth watching. Far from a broken-winged bee, Kirby is so much more than a single reality could ever capture. ■

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Our Time on Earth at London's Barbican Centre combines art, science, design and music to reveal how technology can connect us to the beauty and complexity of the natural world. From 5 May.



Read

Travels with Trilobites by palaeontologist Andy Secher explains how this versatile undersea arthropod came to dominate the oceans for more than 270 million years, and features hundreds of photos of unique fossilised specimens.



Visit

Alienarium 5, now at London's Serpentine South Gallery, is artist Dominique Gonzalez-Foerster's vision of what life would be like if first contact with aliens went superbly well – an "anti-War of the Worlds vision", in her words.

The games column

Post-apocalyptic adventures *Horizon Forbidden West* continues the story of Aloy, a hunter in a future world ravaged by climate change and dominated by robotic animals. It is even better than its predecessor, says **Jacob Aron**



Jacob Aron is New Scientist's news editor. Follow him on Twitter @jjaron



GUERRILLA GAMES

In *Horizon Forbidden West*, Aloy is still hunting for a way to fix her world

style politicking between warring tribes, but an early twist really compelled me to see more.

All of this is supported by the amazing world Guerrilla has built, spanning snowy mountains to dry deserts. Stumbling across a village and realising it is built on top of a ruined solar thermal energy plant was a particular highlight, and it is a lot of fun to get around the world thanks to Aloy's holographic glider, a new addition to the series.

There are also a host of activities to try, including hunting down black boxes from crashed aircraft in order to gain nuggets of story, playing a chess-like board game or taking on human opponents in sparring matches dotted around the map.

The real star of the show, though, is the robotic bestiary. Each machine is an incredibly detailed creation, generally mimicking a real-life animal, but sometimes mashing together different beasts to form creatures like the Rollerback, a cross between an armadillo and an ankylosaurus. My favourite is the Slitherfang, a giant, imposing snake that curls around towers.

Fighting them is always a puzzle as you look for chinks in their armour plating, or you can gradually learn to override their programming and make them fight on your side. Aloy has a range of bow-based weapons with additional tricks, allowing her to shoot globs of glue or even electrified ropes to tie a machine down. My most memorable battle was probably going toe to toe with a robotic *T. rex* in the middle of a dust storm as it fired laser beams from its jaws. Realistic it isn't, but it is an awful lot of fun. ■



Game

Horizon Forbidden West

Guerrilla Games
PlayStation 4 and 5

Jacob also recommends...

Game

Far Cry 3: Blood Dragon

Ubisoft
PC, PlayStation 3 and 4,
Xbox 360 and One

This 80s-infused spin-off to the Far Cry series sees you up against dragons that shoot lasers from their eyes.

Game

Monster Hunter: World

Capcom
PC, PlayStation 4, Xbox One

This monster-hunting series can be pretty obtuse with some archaic game design choices, but World is the most accessible yet.

IT IS a quirk of video games that the sequel is often better than the original. Unlike film directors struggling to produce a follow-up to an unexpected hit, video game developers benefit from the iterative nature of software to improve on their first efforts.

With *Horizon Forbidden West*, the sequel to *Horizon Zero Dawn*, there wasn't much that needed improving – the original was a rare open-world game where I felt compelled to see and do everything on offer, because I was enjoying it so much. Still, developer Guerrilla Games has managed to do so all the same.

The first instalment told the story of Aloy, a hunter in a post-apocalyptic world ravaged by climate change and dominated by robotic animals. She finds a Focus, essentially a very high-tech Bluetooth headset, that allows her to analyse and control the machines, and sets out to discover and fix what happened to the world over 1000 years ago.

Forbidden West picks up six months after *Zero Dawn*'s conclusion, with Aloy still

attempting to restore her world by tracking down a set of powerful artificial intelligences designed to fix the failing ecosystem.

This wasn't the only solution that past generations tried, though – early on in the game, as you explore a ruined office building, you come across an ancient hologram recording of

“My most memorable battle was probably going toe to toe with a robotic *T. rex* in the middle of a dust storm”

a Mark Zuckerberg-like tech bro, explaining his plan to launch a colony ship full of billionaires and escape the dying Earth.

These two approaches to solving problems – essentially, collective or individualistic – make up the narrative spine of the game, as Aloy encounters various people and groups who need her assistance, or who refuse to help in her quest. Some of this gets a bit confusing at the start of *Forbidden West* as you are thrust into *Game of Thrones*-



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Could you be part of an ambitious team seeking to harness the full potential of AI, machine learning and autonomy in support of a sustainable ocean future? Plymouth Marine Laboratory (PML) is a world-leading marine research charity, committed to the pursuit of research excellence to support our vision of a healthy and sustainable ocean.

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To discuss the role in more detail please contact Steve Widdicombe, swi@pml.ac.uk

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- A track record of securing research funding
- Experience of conducting social or natural science within an interdisciplinary setting.

To discuss the role in more detail please contact Steve Widdicombe, swi@pml.ac.uk

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- Experience with digital twins, data visualisation and Artificial Intelligence desirable.

To discuss the role in more detail please contact Tim Smyth, tjsm@pml.ac.uk

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Ageing upturned

New insights into the ageing process show that growing older might not be a one-way street, reports **Claire Ainsworth**

IT WAS as if someone had turned back time. Once-faltering paws gripped objects with renewed strength. Hearts and livers regained their youthful vitality. Fuzzy memories sharpened. And according to Steve Horvath's experiments, the biological age of his rats had been cut in half. "I was stunned," he says.

Horvath, an anti-ageing researcher at the University of Los Angeles, California, saw these startling effects in 2020 after injecting old rats with blood extract from younger rodents. And he isn't alone. A growing number of labs are reporting findings that indicate we might have been thinking about ageing the wrong way.

Rather than the result of the accumulation of wear and tear as time ticks by, ageing could be driven by the forces that build our bodies in the uterus and maintain them after we are born. In youth, they help us, but a failure to switch them off brings the deterioration of old age. This new view offers a deeper understanding of what ageing actually is and the possibility of slowing or even partly reversing it.

While the processes that drive ageing are a matter of debate, biogerontologists do agree on one thing – what it looks like: the progressive decline in physical function that most creatures experience with the passage of time. They have catalogued the cellular changes accompanying this decline, which include crumbling chromosome ends, damaged and unstable genomes and changes

in the way that cells sense nutrients.

For many years, biologists have favoured the idea that these hallmarks were the result of damage such as that wrought by reactive molecules called free radicals produced by our cells' metabolism. This seemed to explain why limiting the amount of food that rodents eat slows ageing and extends lifespan: the metabolic rate of food-restricted animals slows, reducing the production of free radicals. Similarly, drugs that hamper the ability of cells to sense nutrients, via a protein called mTOR that regulates metabolism, also confer longer life in lab animals.

Damage limitation

However, researchers have started to poke holes in this idea. For instance, manipulating the levels of free radicals in lab animals doesn't shorten or lengthen lifespan in a way that is consistent with them being the major driver of ageing. Meanwhile, geneticists have made a series of startling discoveries of gene mutations that have dramatic effects on lifespan, suggesting that ageing is under genetic control. Many of these genes are involved in controlling growth, a key developmental process. "I think ageing is a programme. It is not random wear and tear," says Wolf Reik at the Babraham Institute near Cambridge, UK.

This has prompted some researchers to revamp an idea first mooted in the 1950s – that





SHUTTERSTOCK/MICROONE

ageing can result from the same processes that control our development. “I’m not claiming that all characteristics of ageing are caused by these developmental mechanisms going haywire,” says João Pedro de Magalhães at the University of Liverpool, UK. “I’m saying that there’s this notion that ageing is mostly a consequence of damage. I don’t really think it fits with all the data that’s emerging.”

The idea is that developmental processes that boost an organism’s ability to survive and reproduce earlier in life keep on running, becoming pathological as time goes by. One example of this is how the lenses in our eye continue to grow throughout adulthood, resulting in long-sightedness in middle age. Another is to do with the natural pruning of connections between neurons that happens in an infant’s developing brain. De Magalhães suggests that the run-on of this process in late adulthood could contribute to cognitive decline. And the bone loss experienced by women after the menopause could result from the continuation of processes that draw calcium from the skeleton to support milk production in breastfeeding mothers, suggests David Gems at University College London.

Unlike the damage hypothesis, which is based on cells losing functions, the developmental hypothesis of ageing involves cells keeping functions, but deploying them inappropriately. “Things are making sense in the most wonderful way they never did in the era of the damage maintenance paradigm,” says Gems. This helps to explain why so many of the genes related to ageing are involved in things like growth, he says. It also offers a simple reason why dietary restriction, or drugs that shut down mTOR, delay ageing. Rather than reducing metabolic-related damage, these are instead putting the brakes on growth and other developmental processes by turning down the signals that drive them.

Experimental evidence to support this idea is coming in. Vadim Gladyshev and his team at Harvard Medical School, for example, recently showed that giving newborn mice a drug called rapamycin, which inhibits mTOR, slowed their growth, delayed their reproductive maturity and seemed to help males in particular live longer – all consistent with there being a link between the pace of development and ageing. And experiments in worms suggest that turning down some growth-related





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Secrets of the immortal jellyfish

“Only the gods can never age, the gods can never die,” wrote ancient Greek playwright Sophocles. He had clearly never met *Turritopsis dohrnii*, a small, translucent sea creature whose ability to reverse its life cycle has earned it the nickname “the immortal jellyfish”.

Since this unusual talent was discovered in 1996, this creature has been hyped as holding the secrets to cheating death. In reality, we are only just beginning to discover its mysteries.

***T. dohrnii* begins life as free-swimming larvae, before settling on the seabed to form colonies of polyps. These reproduce by budding off adult forms called medusae – the familiar form of jellyfish, with bell-shaped bodies and trailing tentacles. Medusae usually die after a few rounds of reproduction, but if injured or stressed, can reverse back to the previous step of their life cycle to form polyps again, rejuvenating themselves in the process. By repeating this cycle, *T. dohrnii* can, in theory, live indefinitely.**

The trouble is that the jellyfish is very hard to keep in the lab, meaning few scientists have studied it in detail to find out how it pulls off this trick. But there are some clues. To identify the genes involved with reverse development, Maria Pia Miglietta at Texas A&M University and her colleagues monitored gene activity in the different stages of *T. dohrnii*’s life cycle. They found that while normal polyps and reversed polyps appear physically similar, they activate different suites of genes. Reversed polyps, for example, ramp up genes related to development, making *T. dohrnii* a fascinating natural example of cellular reprogramming and rejuvenation (see main article).

***T. dohrnii* isn’t the only creature touching immortality. A cousin of jellyfish, hydra, doesn’t seem to age at all, a feat it appears to achieve by replacing its entire body every three weeks. This strategy is so successful that it could live for more than 1000 years.**

genes later in life can also extend lifespan.

If ageing is linked to development, it raises the startling possibility that ageing is potentially more malleable than we once believed. If we could find ways to slow or turn off errant programmes, or even throw them into reverse gear, then this could be a route to undoing some aspects of ageing.

This isn’t as far-fetched as it sounds. At least one animal can do this naturally: the so-called immortal jellyfish, which can revert back to an earlier stage of development, seemingly becoming younger in the process (see “Secrets of the immortal jellyfish,” left). And during the earliest stages of development, the human embryo, conceived from the cells of much older parents, reverses cellular signs of ageing and starts its life freshly rejuvenated.

Harnessing this power later in life is fast becoming a key focus of ageing research. There is, however, no way we can reverse our entire bodies backwards from adult to infant (and lots of reasons why we wouldn’t want to). But what scientists have been able to do is reverse one aspect of development: the process by which immature embryonic cells acquire their specialised adult functions. By doing so, they have also reset their biological age.

Resetting the clock

In 2006, Shinya Yamanaka and Kazutoshi Takahashi at Kyoto University in Japan discovered that if four proteins – now known as Yamanaka factors – that are usually only active in early embryos are added into adult cells, this makes them gradually “forget” their specialised adult functions. Back in an embryonic-like state, they can again form any kind of cell in the body, similar to how the immortal jellyfish reverts to an earlier stage in its development. Horvath has found that these “pluripotent” cells have another intriguing property. When he applied a measure of ageing, known as an epigenetic clock, to them, he found that the clock had reset itself to zero.

Epigenetic clocks rely on a chemical alteration that mammalian cells make to DNA, called methylation. Horvath’s team discovered that the pattern of methylation across a cell’s genome changes over time and that it matches chronological age with surprising precision.

Scientists are still trying to understand what

controls these clocks and whether they are a cause or a consequence of ageing. But several clues point to development being involved. In an embryo, cells make a series of decisions about what kind of cell they are going to be. They do this by selectively switching on or off sets of genes – a process that is controlled by the proteins that package DNA, or by altering the DNA itself via methylation. Methylation marks tend to stay put, allowing cells to “remember” what genes should be active.

Many age-related methylation marks are associated with developmental genes, and the rate at which the clocks “tick” varies. It is fastest during development and runs more slowly during adulthood – a feature common to all mammals. “This does point towards the role of developmental mechanisms driving ageing,” says de Magalhães. If taking cells back to a pluripotent state also resets their epigenetic clock, it raises the tantalising possibility that undoing cell specialisation could somehow also undo aspects of cellular ageing.

But there is a snag. When cells are reprogrammed and lose their specialised functions, they often turn cancerous. This is exactly what happened when researchers first tried switching on Yamanaka factors in mice. By tweaking the dose of factors, however, they managed to reduce tumour formation. Then,



LENNART NILSSON, TTS/SCIENCE PHOTO LIBRARY

The processes that build our bodies in the uterus may also drive the diseases of old age

in 2020, a team led by David Sinclair at Harvard Medical School switched on three factors in the retinas of older mice, improving their age-related loss of vision and demonstrating the feasibility of rejuvenating cells without fully reprogramming them.

A flurry of recent findings are backing this up. For example, Reik and his colleague Diljeet Gill at the Babraham Institute have discovered that rejuvenation takes place early on in the reprogramming process, before cell specialisation is irretrievably lost. Working with connective tissue cells called fibroblasts taken from middle-aged adults, they gave the cells a two-week pulse of Yamanaka factors and showed earlier this month that this reversed their epigenetic clocks by about 30 years.

The cells temporarily “forgot” what they were, turning on some pluripotency genes and turning off some of their fibroblast genes. Then, after four weeks, they returned to their usual state, albeit epigenetically younger. “They do somehow remember their original cell type,” says Gill. And that wasn’t all. Patterns of gene activity reverted to a younger type and these changes affected the cells’ function too: they produced youthful levels of a key connective tissue protein called collagen. When Gill and Reik scratched the layer of cells in the dish – effectively creating a wound – the rejuvenated cells were quicker to crawl back over the scratch and close the wound than their aged counterparts.

Groups elsewhere are reporting similar findings. Last year, a team led by Jacob Kimmel at Calico, a biotechnology firm in California aiming to develop interventions to extend lifespan, also managed to rejuvenate adult cells without fully reprogramming them, this time by using subsets of Yamanaka factors. And last month, a team led by Juan Carlos Izpisua Belmonte at the Salk Institute in California and Altos Labs, a biotech company focusing on cellular rejuvenation, used genetic engineering to switch Yamanaka factors on and off at will in healthy, aged mice and reported seeing epigenetic rejuvenation in certain tissues.

Other researchers have managed to produce epigenetic rejuvenation in rodents via the rather macabre method of connecting the blood circulations of old mice with those of young ones and, in Horvath’s case, by also using blood plasma injections.



Could our growing grasp of ageing help prolong our youth?

SEAN JUSTICE/GETTY IMAGES

“It might be possible not just to slow ageing, but to partly reverse it”

How the young blood has this effect is still to be fully elucidated, but, like reprogramming, it involves changes in the pattern of methylation seen at specific sites across the genome. It is also accompanied by alterations in gene activity to a more youthful state and, most convincingly in terms of an anti-ageing perspective, a boost in physical function such as improved muscle strength and bone repair.

For now, there are still many questions about the true meaning of epigenetic rejuvenation. Likewise, what is happening in cells with rewind clocks is unclear. But whatever is going on in these reprogramming and young blood experiments, it isn’t a complete reversal of all ageing. Gill and Reik, for example, found that the shortened chromosome ends – a hallmark of ageing – weren’t restored in their rejuvenated cells.

It is early days in our attempts to manipulate ageing, but one thing is clear: ageing is a complex process involving many factors and we should be wary of thinking in terms of simple fixes to turn back the clock. It is likely

that other factors, including damage, also have their part to play in making us age.

But it does seem that human ageing is more malleable than we once supposed. A plethora of biotech companies have now sprung up, aiming to use this flexibility to forge new approaches to preventing or treating the declines of old age, such as age-related muscle loss, neurodegeneration and osteoarthritis.

In the short term, Gill envisages rejuvenating skin cells from someone and then transplanting them back to treat conditions such as wounds, burns and ulcers, without the risk of tissue rejection. And if we can work out how errant developmental programmes drive ageing, the implication is that we could find ways of turning them off without causing problems elsewhere. “I think there are prospects where you can intervene in developmental mechanisms of ageing in a way that there isn’t a cost,” says Gems, although he cautions that, at present, there is no clear evidence of overall plasticity in human ageing that could be tapped into easily. “I think what’s exciting is the prospect of actually understanding the biology of ageing. Then, who knows what will be possible.”

Longer term, and much more speculatively, de Magalhães wonders whether the technology might be used to rejuvenate whole organisms, including humans. “I think it’s one of the most exciting questions in the field.” ■



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IT WAS shocking,” says biologist Galo Zapata-Ríos, recalling what he saw when he viewed footage from his camera traps. Placed in the Andes, across 2000 square kilometres of forests, grasses and shrublands in Ecuador, these were intended to capture the movements of striped hog-nosed skunks, mountain coatis and other wildlife. Instead, in frame after frame, he saw something he hadn’t anticipated: dogs. “There were so many dogs that I decided to switch my topic,” says Zapata-Ríos, who works for the Wildlife Conservation Society’s Ecuador programme, and now studies the ecological impacts of dogs.

It isn’t just the Andes: dogs are everywhere. They live on every continent except Antarctica, and inhabit high mountains, tropical rainforests, islands and nature reserves that would otherwise be considered pristine. One calculation put their numbers at a billion, making them the most common carnivore on Earth. That was in 2013 and there are surely more today. India alone has seen an estimated

increase of 20 million – to around 80 million – partly because of legislation passed in 2001 forbidding the relocation or killing of street dogs. Meanwhile, during pandemic lockdowns, dog ownership soared in some countries including the UK where there are now some 13 million pet dogs.

At a time when nature is under pressure like never before, there is growing evidence that dogs – both free-roaming and home-based – are killing, eating, terrifying and competing with other animals. They pollute watercourses, over-fertilise soils and endanger plants. Such is their impact that some ecologists call them an invasive alien species. They may be our best friends, but some say we need to take dogs in hand.

From chihuahua influencers to savvy street canines, all dogs belong to the same species. They may have been living alongside humans as early as 30,000 years ago and accompanied us around the world, reaching Europe, North America, Asia and the Middle East at least

10,000 years ago, Australia between 3500 and 5000 years ago and Amazonia and some islands within the past few centuries. Today, only around a quarter of dogs are home-living companion animals, although many more are owned or affiliated in some way with a household or village. Few are truly feral, says Abi Vanak at India’s Centre for Biodiversity and Conservation. They are almost always dependent on humans – if only for the occasional night garbage raid.

The animals caught by Zapata-Ríos’s camera traps were a mix of feral and free-roaming village dogs. What he wanted to know was whether they were pushing out the wild carnivores or muddling along happily with them. The answer was unequivocal: the presence of dogs predicted the absence of pumas, bears, foxes and skunks more powerfully than habitat loss or fragmentation did. “The results suggest that the impact of feral dogs on wildlife in the Ecuadorean highlands are widespread and that free-

Bad dog!

Free-roaming canines and even pet dogs are taking a terrible toll on wildlife, as **Aisling Irwin** discovers



ranging dogs are a significant threat," he says.

Zapata-Ríos went on to discover that, in Ecuador's Cayambe Coca Ecological Reserve, several mammals have altered their foraging times, apparently to avoid dogs. This will have knock-on effects. Animals usually active in the daytime that are forced to venture out at night experience increased fear and stress. "That is going to decrease fertility rates, and that's going to affect population levels," he says. "I really think there is a threat to survival."

Free-roaming dogs, it is emerging, wander through protected reserves in many parts of the world including Iran, Brazil and Italy. They inhabit giant panda reserves in the Qinling mountains of central China, and in India's tiger reserves they outnumber the tigers, according to Vanak. Many studies show that the presence of dogs correlates with decreases in native fauna and flora – although some, for example in North America, have found no link. Careful research is needed to establish whether dogs are to blame, but the list of possible mechanisms

is long. Dogs may kill to eat or to eliminate competition. They destroy eggs. They scavenge, which might seem harmless, but can deprive other animals of a meal. And, as in Cayambe Coca, dogs create fear. The effects of fear are insidious: stress dampens the immune system, constantly fleeing and returning uses up energy and no-go zones reduce the amount of usable habitat. All these pressures can end up slashing populations of wild animals. What's more, the problem isn't confined to remote reserves and free-roaming dogs.

For a pet dog, there is little as exciting as pounding, unleashed, across a seashore driving hundreds of birds into an airborne cascade. At Holkham National Nature Reserve in Norfolk, UK, where shorebird numbers have dropped by 60 per cent in the past two decades, Jake Fiennes, its director, knows the havoc this can cause. In 2019, the reserve attracted 800,000 visitors – and 300,000 dogs. But in spring 2020, a covid-19 lockdown meant the birds had the beach to themselves. "Seeing 10,000 shorebirds merrily feeding away ➤



It looks like harmless fun, but dogs do ecological damage chasing shorebirds



How to be an eco-friendly dog owner

because there's no disturbance was very emotional," says Fiennes. That ended abruptly in June when 35,000 stir-crazy visitors escaped to the beach over a single weekend. It was peak breeding season with a lot of nests on the shore. "The impacts were devastating," says Fiennes.

Birds, it turns out, seem to be particularly sensitised to dogs – even on leads. In woodlands outside Sydney, for example, a study found that people walking leashed dogs caused a “dramatic” reduction in the diversity and abundance of birds – more than double that caused by the same number of people walking without pets. These birds didn't become habituated to the presence of these dogs – possibly because the occasional off-lead dog regularly resensitises them, the authors speculated. Some birds are more easily disturbed than others. Another study found that the space required by different species before they are disturbed varies from 500 metres to a mere 40 metres.

Ecological paw print

Even the least scary dog can leave a footprint. This was accidentally but vividly demonstrated in a nature reserve in Kent, UK, where a fence that bisects a pond confines dogs to one half. On the undisturbed side, aquatic plants, including the critically endangered three-lobed crowfoot, flourish. On the other, enthusiastic dogs have churned up the sediment, destroying almost every plant – and thus banishing the aquatic animals that shelter in them.

Turbidity isn't the only thing dogs leave in their wake. Their excreta can be a problem on moorlands and fens, deep inside some woods and even on road verges. That is because the plants in these habitats need soils low in nutrients to survive, says Pieter De Frennes at Ghent University, Belgium. In February, he published calculations of the amount of nitrogen (from faeces and urine) and phosphorus (from faeces) that dogs were depositing into four popular nature reserves around Ghent. Assuming that owners scooped half the faeces, it came to 8 kilograms of nitrogen per hectare per year and more than 1 kilogram of phosphorus.

Whether this matters depends on an ecosystem's critical deposition load – the amount of extra nutrients it can tolerate. In three of the reserves, the critical load for

Read signs and posters and follow the advice: there may be reasons you haven't thought of why dogs could damage the surrounding ecology.

Always keep your dog to paths on dunes to minimise erosion, bird disturbance and trampling of plants.

Keep dogs out of ponds, especially small ones, which are easily disturbed, and those in nature reserves and national parks, which often harbour rare and threatened species.

During bird-breeding seasons, ensure your dog doesn't disturb nests, particularly on dunes, beaches, moorland and heath, where ground-nesting specialists are found.

Train your dog to return to a call and not to stray out of sight in ecologically sensitive areas.

Always pick up faeces. Much of the countryside could do without the extra fertiliser and it may carry diseases or contain medications that kill insects and arachnids.

To further prevent toxic chemicals entering waterways, consider reducing your dog's prophylactic treatments with flea, tick and worm tablets. Regularly washing bedding and checking for fleas instead can reduce the risk of infection.

The mere presence of dogs – even on leads – can reduce biodiversity



SHUTTERSTOCK/LOPOLO

nitrogen is 20 kilograms per hectare, and that is already exceeded by the 22 kilograms per hectare being deposited from the atmosphere. So dog waste has “an important additional impact”, says de Frennes. “The presence of dogs in these reserves will certainly delay restoration goals.” He suspects that the problem may be widespread. The critical loads of nitrogen and phosphorus on moorlands and fens, for example, are much lower, so it doesn't take many dogs to stress these ecosystems.

Wherever dogs make their deposits, there is also the risk of passing infections to wild animals. In 2015, in Ethiopia's Wollo highlands, rabies killed seven endangered Ethiopian wolves from a small pack of 13. A rabid dog found dead nearby indicated the source of the infection. Conservationists managed to track down and vaccinate two of the surviving wolves – but within two months, one had died from canine distemper virus. Again, a dog was implicated.

Dogs have even been linked to waves of lion deaths in India and in Tanzania's Serengeti national park. In the Alps, both companion dogs and free-roaming shepherd dogs appear to be spreading a cocktail of diseases, including canine distemper, to local wildlife. Even when dogs don't infect wildlife directly in this way, they can act as reservoirs for pathogenic microbes. The key is the presence of many dogs, says Matthew Gompper at New Mexico State University. They can then transmit pathogens repeatedly across the species barrier. Without this, the diseases would probably fade away.

In affluent countries, another worry is the chemicals administered to dogs to combat ticks, fleas and parasites. In the UK, these include a parasiticide that is banned in agriculture, but is nevertheless applied to dogs' coats. Recent research found widespread contamination in rivers with this and another parasiticide also applied to dog coats, leading to fears that they are killing aquatic wildlife. Just bathing a treated dog at home may release the chemicals into rivers via sewage plants.

The evidence seems overwhelming: our hunting, defecating, bird-chasing, pond-paddling, infectious best friends are harming some ecosystems. This may put some people off owning a dog (see “Is it fair to keep a dog?”, right), but, as Gompper points out, our feelings for them run deep. Even street dogs have advocates who feed and care for them, says Vanak. And dogs come with all sorts of benefits

Street mutts in Varanasi, India, are among the billion or so dogs on Earth

including fun, protection, love, exercise and – paradoxically – exposure to nature.

So, what to do? Gompper suggests that before getting too anxious, we should assess where dogs are having a population-level effect on a wild species, and where they are just part of the rough and tumble of red and toothy nature. “There’s a general sense that we need to address issues raised by the presence of dogs everywhere and I’m not sure that’s always necessary,” he says. Dogs are most damaging ecologically where they are recent arrivals, because these ecosystems can be defenceless against them: on islands in places such as Hawaii and New Zealand, and in regions like South America, Australia and southern Africa.

There is also little doubt that dogs cause great harm to certain animals, particularly vultures in India, shorebirds everywhere and marine turtles when their nests are raided. Even in these cases, Gompper argues for pragmatism. There is no point intervening where there is little hope of success – for example, if it will be impossible to vaccinate enough dogs to achieve herd immunity against the diseases they can carry – or where cultural norms mean that people will never accept the curbs necessary to make a difference.

Where action is urgent, it is likely that it can only succeed if it reconciles the needs of dogs, owners, welfarists and wildlife. This isn’t



ARPAN BHATTIA/VEEM/GETTY IMAGES

“Such is their impact, some ecologists call dogs an invasive alien species”

happening in Indian cities, says Vanak, where “dog wars” pit people focused on animal welfare against conservationists and those concerned about the human toll from attacks and disease. Elsewhere, owners may feel that letting their dog off the leash is a healthy and natural thing to do – and see dog bans, or off-leash bans, as unwarranted interference.

Nevertheless, there are things you can do to limit the ecological footprint of your pet (see “How to be an eco-friendly dog owner”, page 44). And there are things that conservationists can do to help you. Working together is key, as Fiennes discovered. The disastrous impact of dogs on breeding birds at Holkham in 2020 inspired him to consult widely about acceptable changes and then implement a zoning system: “no dogs”, “dogs on leads April to August” and “dogs off leads”. Signposting is clear, frequent and educational, and friendly stewards – and their dogs – wander the beach. A year later, nesting and fledging rates of little terns, oystercatchers and ringed plovers have increased. “It’s trying to balance the need to get people more engaged with our natural environment, but also to ensure that they are well informed of the potential impacts that they can have,” he says. ■

Is it fair to keep a dog?

We have all read stories about mistreated dogs, overcrowded puppy farms and the maladaptive traits that cause suffering in various breeds. Add to that the carbon footprint of dogs and the ecological damage they can wreak (see main story), and you might be left wondering whether we should keep them as pets.

Marc Bekoff at the University of Colorado, Boulder, points out that dogs co-evolved with us over thousands of years, and have developed behavioural, neural,

anatomical and physiological adaptations to living with humans. Besides, pet dogs lead safer, more comfortable, hunger-free lives than they would in the wild. Bekoff believes that it is fine to keep pooches, provided you develop an instinct for what they need. “Make the walk for them,” he says. “Give them sniff time.” He also advises giving your dog time to hang out with you, to have rough-and-tumble play with other dogs and the opportunity to resolve its own doggie conflicts. “Let dogs be dogs,” he says.



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PETER CROWTHER

A new slant on the cosmos

The idea that the universe looks more or less the same in every direction underpins cosmology. What if it's wrong, asks **Thomas Lewton**

IMAGINE you are marooned in a vast, featureless expanse. Everywhere you look, no matter how far you travel, it all looks the same. It sounds like a disturbing dream. Believe it or not, though, this is the universe you live in. If you zoom out far enough, past nearby stars, through the Milky Way to clusters of galaxies and the filament-like structures that connect them, and then you keep going,

eventually, everything starts to look smooth and uniform wherever you glance.

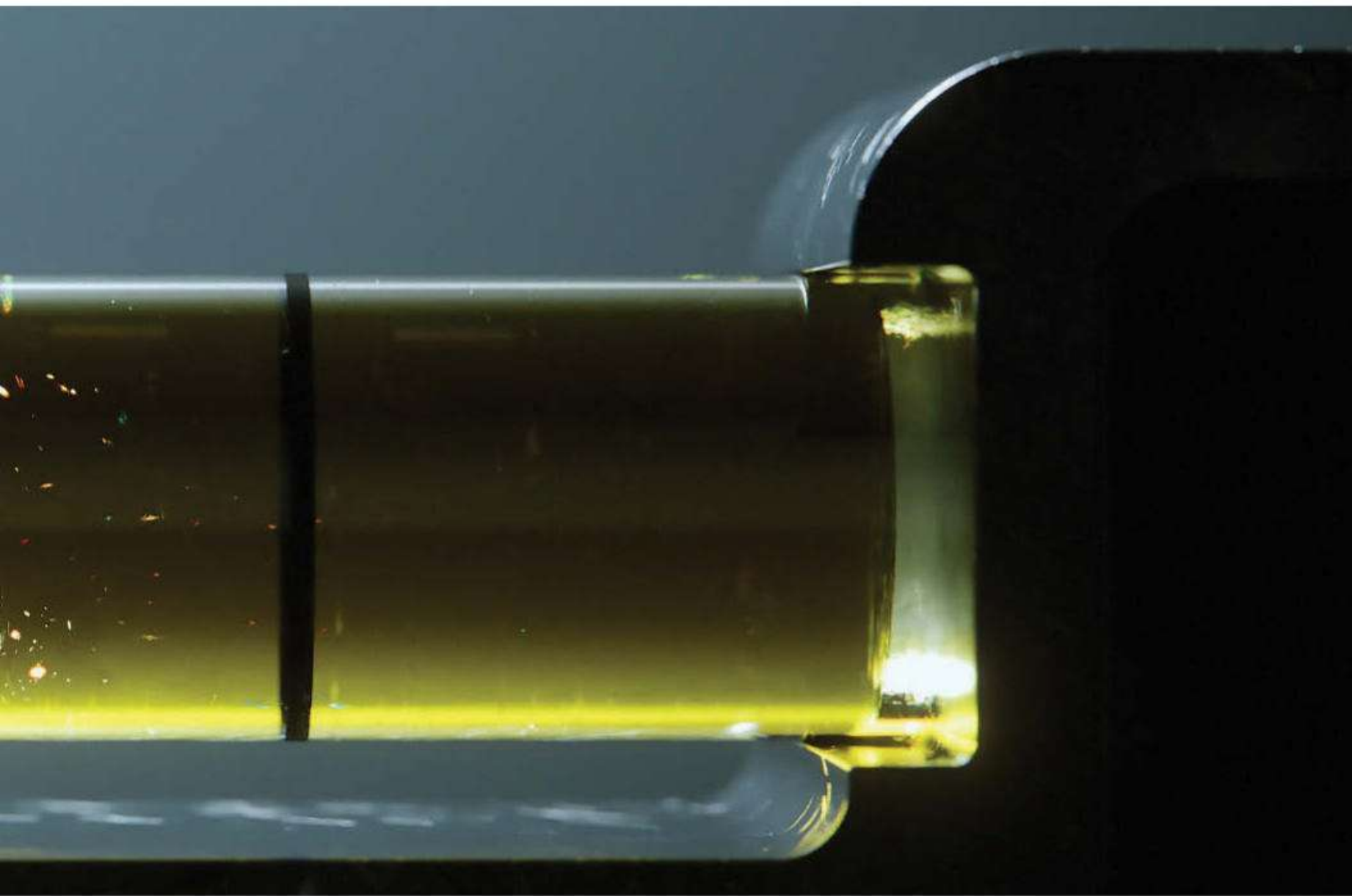
Or does it? This idea that, on the grandest scales, the cosmos looks largely the same regardless of position or direction is called the cosmological principle, and it underpins our best theory of how the universe evolved. For cosmologists, it is gospel. But some heretics are now calling the principle into question,

pointing to fresh evidence that even at its largest scales, the cosmos is not only lumpy, but fundamentally off-kilter.

If they are right, it would upend cosmology. We would have to start our description of the universe's evolution from scratch – and possibly even admit there can be no single model capable of describing it right up to today.

If they are right. Most cosmologists are a long way from convinced. Similar challenges have been seen off before, they shrug. And yet there is a reckoning on the horizon because, one way or another, the cosmological principle – for so long considered untouchable – is finally going to run the empirical gauntlet.

The notion that the universe is the same everywhere in all directions grew out of another essential tenet of cosmology: Nicolaus Copernicus's argument, made in the 16th century, that Earth doesn't occupy a special place in the universe, aka the Copernican principle. But the cosmological principle didn't earn its current exalted status until the 1920s, when it made it possible to extract a workable model of the universe from Albert Einstein's new theory of gravity – general relativity.



General relativity is as complex as it is beautiful. Ten intertwined equations balance matter and energy on one side and the warping of space-time on the other. The only way to solve it is to make sweeping assumptions about how matter and energy are distributed and how space-time warps. By assuming the universe is the same everywhere, or homogeneous, and looks the same in every direction, a feature known as isotropy, physicists were able to boil down Einstein's equations to extract a simple, evolving universe that matched observations.

This "Friedmann–Lemaître–Robertson–Walker" (FLRW) solution enshrined the cosmological principle, and it remains the foundation of the standard model of cosmology – our best theory of how the universe evolved. Starting with the big bang, this perfect FLRW cosmos expands symmetrically like a balloon filling with air. Stars, galaxies and clusters then form by allowing small deviations from what remains an otherwise smooth and uniform cosmos.

The standard model works. When we take a detailed map of light from the very early

universe, known as the cosmic microwave background (CMB), and extrapolate forward using the model, we get pretty much exactly what we observe today. "The same bumps and wiggles that you see in the CMB are present in the large-scale distribution of galaxies," says Jim Peebles at Princeton University, who developed the standard model in the 1970s and 80s. "The standard theory works far better than I ever expected. But I never thought of it as a final theory; it was a placeholder."

The realisation that galaxies seem to be held together by some other kind of invisible matter, known as dark matter, and then the

discovery that the universe's expansion is accelerating, since attributed to dark energy, meant cosmologists had to add a couple of things to their recipe – freehand additions, as it were. "We just say ad hoc: 'Let there be dark energy! Let there be dark matter!'" says Peebles.

Like Peebles, most cosmologists would agree that the standard model is due an upgrade. For starters, we still don't have the slightest clue what these mysterious spectres thrown into the pot to make it work are. And even when we incorporate dark energy into the standard model, direct measurements of stars and galaxies tell us that the universe is expanding faster than it should be according to the model.

Another set of observations suggests we may need to do more than just tinker. For years, a small cohort of cosmologists has been pointing out that the vast, bubble-shaped voids around which galaxies are strung in filaments and clusters make the universe look suspiciously inhomogeneous. The same is true of vast walls made of galaxies and galactic superclusters. Then, last year, the discovery of a giant chain of galaxies stretching 3 billion light years across the sky, known as the Giant Arc, ➤

“The standard model of cosmology was always a placeholder”

gave fresh impetus to questions about the cosmological principle on which the standard model rests.

The argument isn't only that such outliers provide more evidence against homogeneity on the biggest scales. It is also that the gravitational pull of such giant structures is what creates streams of matter that drift like the breeze, known as "bulk flows". These can travel at hundreds of kilometres a second and stretch as far as a billion light years. "There have also been reports of extreme bulk flows, much larger and much faster, but they have not been confirmed," says Christos Tsagas at the Aristotle University of Thessaloniki in Greece, who is building "tilted" cosmological models that include such fast-moving streams of matter.

Tsagas says we are in a bulk flow. We live on Earth, which orbits the sun, which orbits the Milky Way, which is pulled towards Andromeda, the nearest large galaxy to Earth, as well as towards clusters of galaxies like Virgo, superclusters like the Great Attractor and perhaps even lumps of matter beyond the horizon of what we can see. Our perspective is tilted relative to the symmetric expansion of the universe as a whole.

As a result, says Tsagas, we could end up with a false impression regarding dark energy. We see the universe's expansion as accelerating, and yet its expansion could just as well be decelerating overall. Think of driving along a motorway where all the cars are travelling at the same speed when, suddenly, your engine goes kaput and you start to slow down. From your point of view, it looks like the other cars are accelerating away. In a similar manner, if the bulk flow we are in is decelerating, then the surrounding universe would seem to be accelerating – creating the illusion of a mysterious expansive force.

That would be a big deal, of course. But Subir Sarkar at the University of Oxford wants us to go further still. He claims to have found evidence that the entire universe is fundamentally skewed – and therefore that the cosmological principle is broken.

Again, it starts with the CMB, which more or less glows with the same temperature in every direction. Not quite, though. It appears lopsided to us, mainly because Earth is

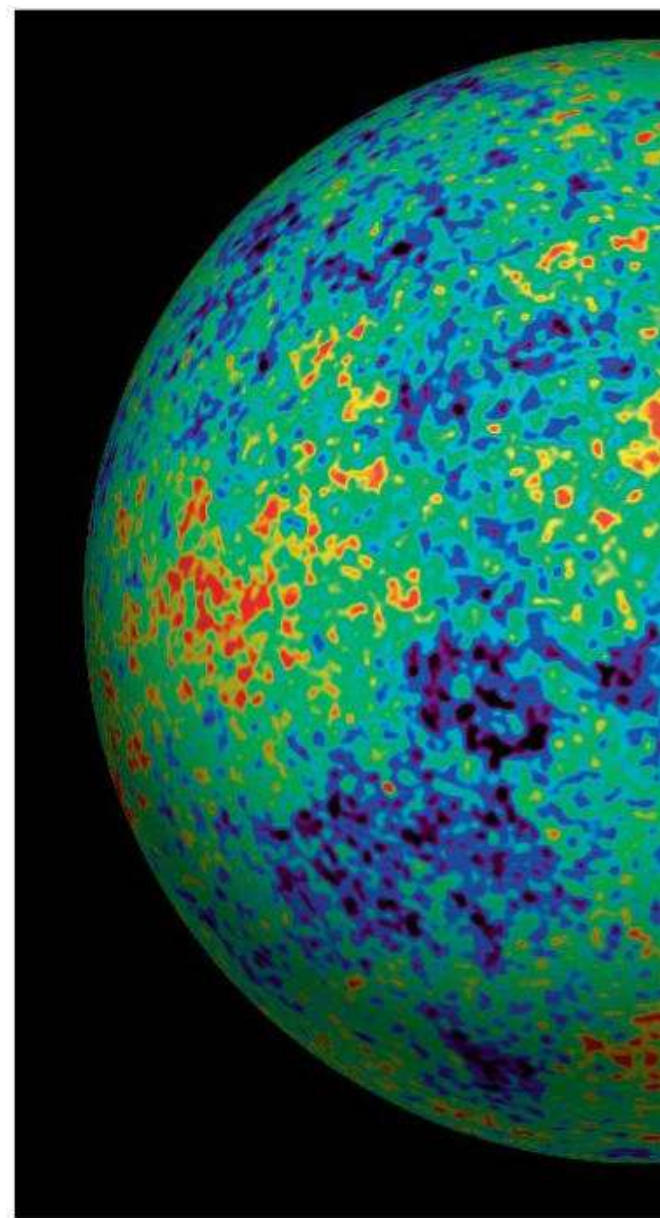
screeching around the Milky Way at hundreds of kilometres a second. Just as the frequency of an ambulance siren is distorted as it speeds past you, the CMB is distorted by our motion in the universe.

In the 1980s, George Ellis, now at the University of Cape Town in South Africa, came up with a way to use this lopsidedness to check if the standard model obeys the cosmological principle. The idea was that we should see exactly the same distortion in very distant galaxies because, like the CMB, distant galaxies act like a fixed background against which we can measure our own motion. "If those two don't match up very precisely, then your standard FLRW model is in deep trouble," says Ellis.

Getting good data on very distant galaxies is tough, as they are so faint and difficult to distinguish amid astronomical objects closer to home. Astrophysicists were eventually able to perform the test in 2002 thanks to a large catalogue of galaxies, called the NVSS, gathered by the Very Large Array telescope in New Mexico. This showed that our motion through the universe agreed fairly well with the CMB. And yet the relatively small number of galaxies, and the ambiguity in how far away they actually are, left room to speculate.

"We realised that a better catalogue was required," says Sarkar, who in 2019 teamed up with Nathan Secrest, an astronomer at the US Naval Observatory in Washington DC. Secrest offered Sarkar and his colleagues a catalogue of 1.4 million quasars, known as catWISE, gathered by the WISE space telescope. Quasars are very bright jets of light powered by supermassive black holes in the centre of galaxies. Compared with the NVSS, catWISE has many more sources spread across the whole sky rather than just a portion of it – important

“If the universe is skewed, it would be ludicrously inconvenient”



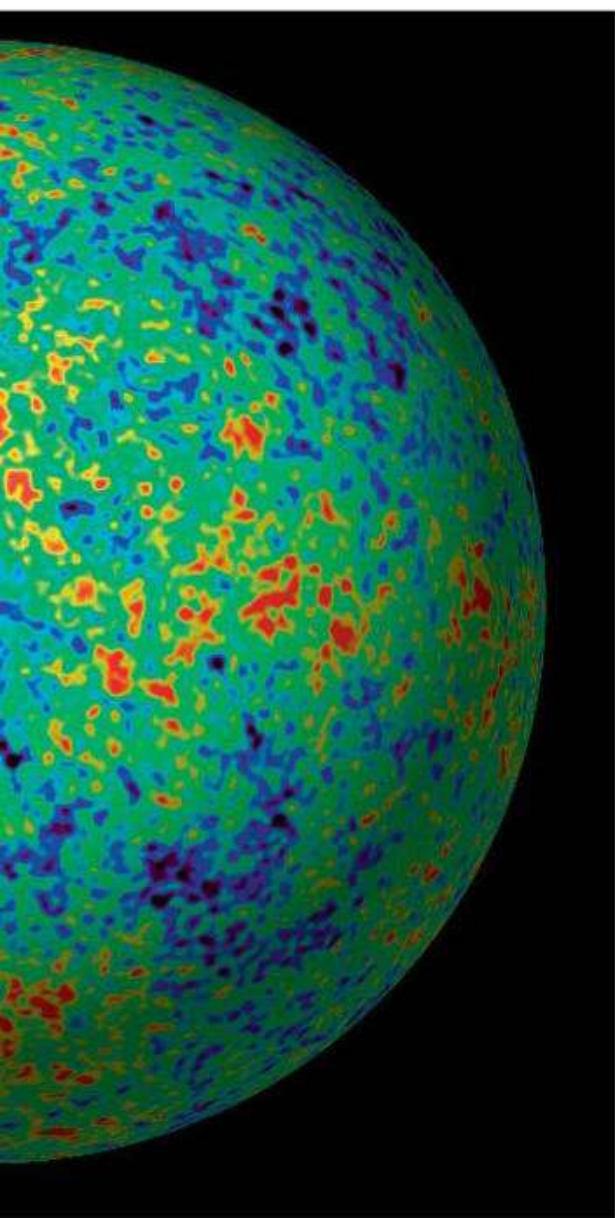
if you are trying to assess how skewed the universe is overall.

Last year, Sarkar, Secrest and their colleagues reported a distortion in the distribution of quasars that was in a similar direction as the CMB's skew, but twice as big as that expected if Earth's motion were the sole cause. The implication is that instead of just bulk flows that drift across large parts of the universe, the entire universe may be drifting too. In other words, according to Sarkar, the underlying scaffold may be fundamentally skewed.

One way to picture it is to imagine that everything is being pulled in a particular direction by something we can't see, though the question of how such a skew might have come about is an open one. It might have been etched into the primordial universe, for instance, or appeared much later when matter clumped together – perhaps on an immense scale outside of our observable universe.

In any case, the implications would be profound. "What we have found in these quasars is questioning the cosmological principle," says co-author Roya Mohayaee at the Paris Institute of Astrophysics in France.

If Sarkar and his colleagues are right, it would also be ludicrously inconvenient. It would mean going back to Einstein's equations



NASA/WMAP SCIENCE TEAM/SCIENCE PHOTO LIBRARY

A spherical map of light from the early universe, known as the cosmic microwave background

along with any of this. “We are in a very unenviable position in that most of our colleagues don’t even want to hear about it,” says Sarkar.

For their part, sceptics point to conflicting or inconclusive results on the question of a skew in the large-scale structure of the universe. “I have not gotten too excited about this,” says George Smoot at the University of California, Berkeley. Others say that studies of such distant objects as quasars are riddled with potential errors. “None of these observations are particularly well verified,” says Chris Clarkson at Queen Mary University of London.

Mohayaee says that such dismissals are “unfair”. “We have put all of our data, our codes and simulations online. I would love to see this proven wrong, so please come and show us,” she says. In soon-to-be-published research, the team has cross-checked its analysis of catWISE with a cleaned-up analysis of the NVSS catalogue to build an even stronger case for a skewed universe.

But even people who think the data and analyses are solid see little reason to seriously consider this possibility. Peebles says that instead of hinting at a skewed universe, the data could be explained if quasars clump together much more than other types of matter on those scales. For now, he says, he remains “deeply impressed by the tight network of well-checked tests” that the standard model passes. It is possible that there is another overarching theory that agrees with all the measurements as well as the model we have, says Peebles. “I can never disprove that, but I can ask myself: ‘Does it seem likely?’”

Sarkar sees no reason why this model, built on the cosmological principle, can’t sit alongside another one, in which the universe is fundamentally skewed. Rather than a single cosmology that describes everything, he argues that different models could be applied at different epochs and then stitched together.

A new generation of telescopes is poised to offer some clarity. Next year, the Vera C. Rubin Observatory in Chile will start making observations and the Euclid space telescope is due to launch. Meanwhile, the Square Kilometre Array keeps adding to its vast network of radio dishes in South Africa and Australia. Between them, these observatories

will scour the night sky, looking at billions of very distant galaxies over a large swathe of sky.

This makes possible a far more precise test of the cosmological principle. Ruth Durrer at the University of Geneva, Switzerland, proposes using different types of measurement from each telescope to untangle whether the lopsided CMB is entirely due to Earth’s motion in the universe or whether there is also a fundamental skew. Another approach would be to test the Copernican principle, from which the cosmological principle grew, by envisioning what the CMB looks like to far-off observers. If our vantage from Earth is nothing special, then the CMB should look the same. “Just a decade or so ago, people were saying it’s a philosophical assumption that can’t be tested, but it really seems that it can,” says Clarkson.

Principles at stake

You do that by studying galaxy clusters, where charged particles divert photons of light from their original path, sometimes sending them hurtling towards Earth. CMB photons that are scattered in this way can give us a rough picture of what the CMB looks like to a hypothetical observer at that galaxy cluster. “If a bunch of different observers see an isotropic cosmic microwave background, it really forces you into the cosmological principle,” says Clarkson – and if they don’t, well, all bets are off.

It isn’t difficult to see why many cosmologists are reluctant to throw out a very successful, albeit imperfect, model of the universe. “People don’t like it if you come into their garden, which they’ve planted for years, and then you step in the middle of the rose bed,” says Durrer.

And yet Sarkar insists that cosmology should be led by observations, rather than dogma. “All the great discoveries have been made by simply building an instrument, pointing it at the sky and looking,” he says. “Astronomy is all about serendipity.” ■



Thomas Lewton is a science writer based in London, UK

to see what other solutions might fit our universe. Other than the smooth and uniform FLRW solution, there are about 20 other options to play with. Some assume the universe is smooth, but not uniform (the Bianchi solutions), some assume it is uniform, but not smooth (the Lemaître-Tolman-Bondi solutions) and some assume it is neither. One idea, called the swiss-cheese model, excavates spherical holes dotted across the universe and fills them with black holes.

“The mathematical scope for looking at these problems is... quite large,” says Gary Gibbons at the University of Cambridge. “But it’s a question of whether or not you feel you get a satisfactory picture.” On the one hand, the freedom in these other solutions should offer ample possibility to solve cosmological puzzles such as what dark energy is, or whether it even exists. On the other hand, no one knows if these far more complicated solutions can match up to the intricate map of the universe we already have.

And therein lies the problem. Switching to an entirely new cosmological framework would require entirely new ways of analysing data that don’t assume all directions are the same – which is one way to explain why cosmologists have been so reluctant to go

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Puzzles

Try our crossword, quick quiz and logic puzzle **p53**

Almost the last word

Why are the green parts of plants good for us? **p54**

Tom Gauld for New Scientist

A cartoonist's take on the world **p55**

Feedback

Investigating the way the cookie crumbles: the week in weird **p56**

Twisteddoodles for New Scientist

Picturing the lighter side of life **p56**

Science of gardening

Field of dreams

Sweetcorn is easy to grow, once it germinates, and produces a tall and majestic crop to impress young gardeners, says **Clare Wilson**



Clare Wilson is a reporter at New Scientist and writes about everything life-science related. Her favourite place is her allotment @ClareWilsonMed

What you need

A propagator – a plastic box with a clear lid

Free-draining compost

Sweetcorn kernels or plug plants

A sunny patch of soil

ANYONE who is just starting to grow their own vegetables might want to consider sweetcorn, especially if they are keen to get children involved. It is, for the most part, easy to grow and the end result of corn on the cob is usually appreciated by all, no matter their age.

At first, I tried the “three sisters” companion planting method, developed by Indigenous groups in North America. This means growing sweetcorn with two other types of plants, squash and beans, and they help each other thrive.

Beans improve soil fertility because, as a legume (like peas and lentils), they have the ability to turn gaseous nitrogen from the air into soluble forms that plants can use. Corn grows up tall, providing a structure for the beans, which need some kind of physical support to climb up. Squashes are a large rambling plant, with big, flat leaves. Once they get going, they help suppress weeds.

As I found out, though, in the cooler and cloudier British climate, growing the three plants in among each other led to them doing poorly. This is probably because they were shading each other too much, says Matt Oliver at the UK Royal Horticultural Society.

If you want to nod to the companion method, Oliver recommends combining corn with just a small-fruited variety of squash, such as “Buffy Ball” or “Little Gem”, which don’t need so much sun to ripen.

Just growing corn by itself



GAP PHOTOS/JONATHAN BUCKLEY

produces a tall and majestic crop that will impress young gardeners. To help the corn plants pollinate each other, grow them in a square patch, rather than in rows.

A sunny patch of soil just 1 metre by 1 metre would be enough to grow about nine plants – almost a corn field.

The only tricky stage is getting the seeds, or kernels, to germinate. As corn is from warmer climes, if planted outside in the UK, the kernels can struggle in the cold, wet soil and go mouldy before they can sprout. Instead, start off the kernels in a lidded propagator, which is a plastic box with a clear lid that can be placed on a sunny windowsill so it acts like a miniature greenhouse.

Use a highly free-draining compost, so the kernels don’t

become too moist, and bury them only 1 centimetre deep, as the top layer of compost will stay drier.

If your best efforts fail, in April and May, garden centres in the UK may sell sweetcorn “plug plants” that look like a large blade of grass, where the germination has been done for you. These can be planted out when the risk of frost has passed.

Once the plants get going, they are fairly resilient, but in summer, it is worth trying to scare birds away from the ripening cobs. I rig up string barriers with dangling shiny things like old CDs. Your reward will be the best sweetcorn you have ever tasted. ■

Science of gardening appears every four weeks

Next week

Citizen science

These articles are posted each week at [newscientist.com/maker](https://www.newscientist.com/maker)

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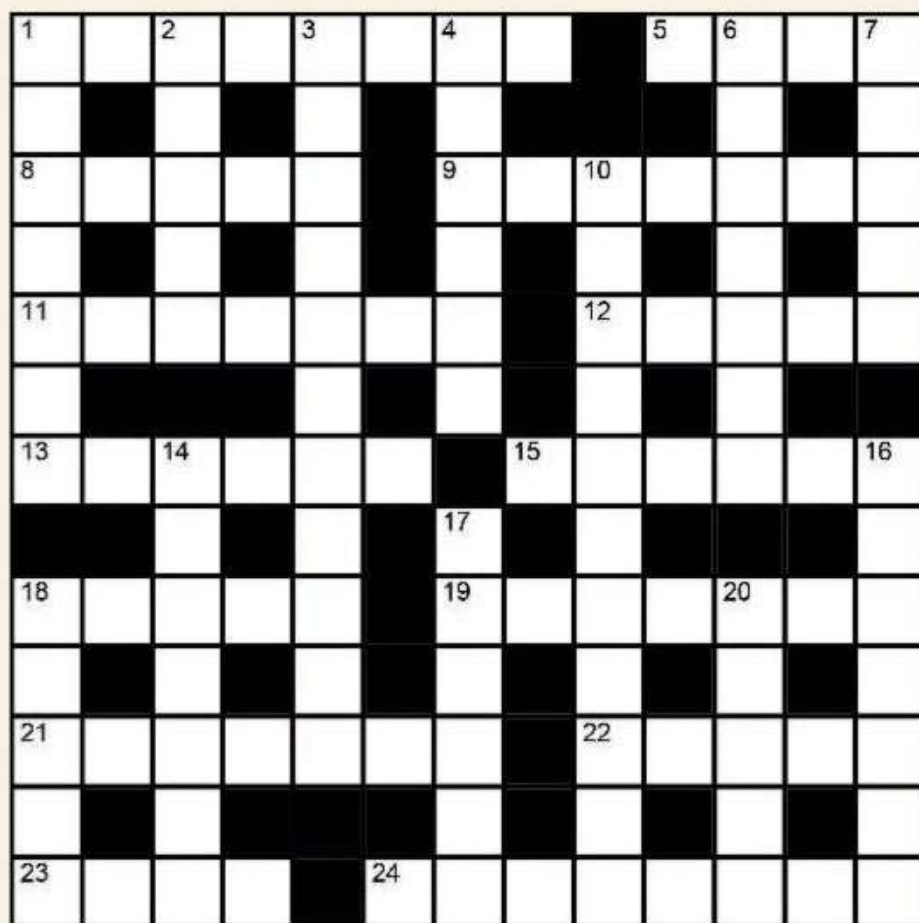
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Cryptic crossword #82 Set by Rasa



Scribble zone

Answers and the next quick crossword next week

ACROSS

- 1 Long, involved story with urban wisdom (8)
- 5 Lacklustre minstrel goes west (4)
- 8 Incandescent light used in heating unlimited water (5)
- 9 Savoury pie ingredients bring back appetite in children (7)
- 11 Draw area of land that's no longer here? (7)
- 12 Elevate beams in the auditorium (5)
- 13 Deposit goo on the road twice (6)
- 15 Stop talking about lowlands' first returning cougar (4,2)
- 18 Explosion destroyed labs at intersection (5)
- 19 Withdraws plants again, we hear (7)
- 21 Perennial call to release bewigged singer-songwriter? (7)
- 22 Vain niece exposes navel (5)
- 23 Carry little one everywhere, in the end (4)
- 24 Red mineral lodging in calcium rod (8)

DOWN

- 1 Most sarcastic hollow slogan that is in Latin (7)
- 2 Transplant procedure is hard work (5)
- 3 Company's acquiring the canal, moving fishes once thought extinct (11)
- 4 Develop a liking for low-carb diet after initially trashing Atkins (4,2)
- 6 Item on the table: chicken I bathed in liquor (7)
- 7 Speaker's located roasting tip (5)
- 10 Neglect acting teacher's concern surrounding revised reel (11)
- 14 On the subject of a fellow with substance (7)
- 16 Regret rising in support of former microbiologist (7)
- 17 Supply weapons to an independent designer (6)
- 18 Wager covers half of fine suit (5)
- 20 Badly need British star in "The Swan" (5)

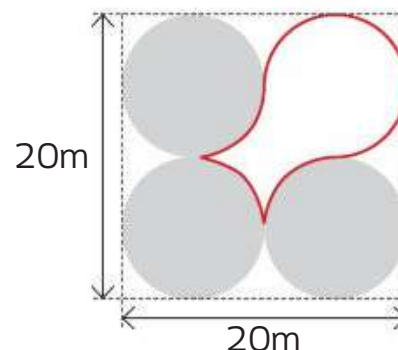
Quick quiz #149

- 1 Which Neptunian moon is known for its highly eccentric orbit?
- 2 What name is given to a woody plant that is rooted in the ground and uses other trees as support to climb?
- 3 The duodenum, jejunum and ileum are the three sections of which human organ?
- 4 The Fujita scale measures the intensity of which extreme weather events?
- 5 Which of the following dinosaur genera isn't classed as a sauropod: *Brachiosaurus*, *Patagotitan* or *Spinosaurus*?

Answers on page 55

Puzzle

set by Howard Williams
#165 Land for rent



Penny Wise, chief financial officer of the Hartree Power Company, has decided to rent out surplus land beside its cooling towers, in an effort to boost her company's annual income. The land, outlined in red on the plan above, was to have been for a fourth tower, which is now no longer required, plus the land between the three existing towers.

Her legal officer has been tasked with preparing the rental agreement, but is having difficulty in calculating the area of land for rent. Can you help?

Solution next week



Our crosswords are now solvable online
newscientist.com/crosswords

Green eating

We are told “eat your greens”, but is there any reason why the green parts of plants are an essential part of our diet?

Tim Spector

Author of Spoon-Fed: Why almost everything we’ve been told about food is wrong, King’s College London, UK
We know eating plants is good for us. In fact, the more the merrier. The ideal number for good health and our gut microbes is 30 different plants per week.

This isn’t as hard as it seems because this total includes nuts, seeds, fruits, legumes, beans, whole grains and many other plants that aren’t green and yet confer health benefits. But why eat your greens above all else?

Plants get their colour from a range of chemicals that help them thrive and survive. These polyphenols, such as the red and blue anthocyanins, green chlorogenic acid and yellow quercetin, are also the compounds

“Increased green leafy vegetable intake is associated with reduced cancer risk and improved cognitive health”

that we need to stay healthy.

There are hundreds of different polyphenols in brassica vegetables such as kale, broccoli, rocket and cabbage. All of them have different beneficial impacts on our health thanks to their powerful effect on our gut microbiome. This community of microbes that lives in our large intestine uses polyphenols to make helpful chemicals known as postbiotics that affect everything from our immune response to our mental health.

Decades of evidence shows that increased green leafy vegetable intake is associated with improved health outcomes: from reduced cancer risk to improved cognitive

health, a lower risk of type 2 diabetes and better outcomes for pregnancy. All of this is thanks to the polyphenols and other nutrients that are found specifically in the colourful green leaves, in addition to another key ingredient that also feeds our gut microbes: fibre.

As well as being high in fibre and polyphenols, greens are low in a form of carbohydrate called starch. Unlike potatoes, carrots, corn and beetroot, which have enough starch in them to cause a spike in blood glucose levels and alter our glucose metabolism and hunger, greens don’t have this effect and so can be enjoyed freely. What’s more, as I discuss in *Spoon-Fed*, there are leafy greens in season all year round.

Although the green parts of the

plant have a high concentration of polyphenols, dark red or purple leaves can sometimes have even higher levels. But making sure we “eat our colourful greens” is the simplest way to remember to consume plenty of different polyphenol-rich, non-starchy plants all year round.

Jan Brady

Sydney, New South Wales, Australia
Are the green parts of plants an essential part of our diet? The simple answer is no. In fact, they can be dangerous for certain people, due to the vitamin K1 concentrated in these foods. This vitamin helps with blood clotting and wound healing, but for those of us on the blood-thinning medication warfarin, the vitamin K1 content of fresh greens is



FLPA/SHUTTERSTOCK

This week’s new questions

Dew time My washing is hanging to dry outside and I need to bring it in before dew forms on it. How do I know at what time or temperature that will be? **Clare Wilson, London, UK**

Wagging question Why do wagtails wag their tails? They would be well camouflaged, if it weren’t for their constantly moving tails. **Mick Groves, Oxhill, Warwickshire, UK**

Wagtails got their name from their constant tail wagging, but why do these birds do this?

an antidote to the medicine.

I found this problem so frustrating that I recently published a cookbook for people on warfarin, explaining the options available to ensure safe eating habits.

All the vitamins and minerals contained in green vegetables can be found in other foods, but with lower concentrations of vitamin K.

Lichen this sign

Why are the lichens distributed in this way on this road sign (pictured right)? The surfaces have the same texture, just different colours.

Steph Györy

Sydney, New South Wales, Australia
The lichens on this sign are clustered on the black for the same reason that lichens prefer the sunnier side of a tree trunk: they are attracted to the heat. Black absorbs more sunlight than the white or red areas of the sign.

Filbert Grottoon

Winston-Salem, North Carolina, US
The black paint will get more warmth from sunlight, but perhaps this answer is too simple. The special piece of the puzzle is what happens to the black area of the sign when it warms. It expands at a greater rate than the surrounding parts and this causes its paint layer to crack slightly more than theirs. These fine cracks allow the lichen to gain the foothold needed to flourish.

Mark Powell

Bedford, UK
My investigation of this phenomenon leads me to contradict the assertion that the black symbols (including lettering) of UK road signs have the same texture as the pale background.

I looked at sections of sign lettering under a microscope and this revealed a roughness such as minute pockmarks or cracking of



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Tom Gauld
for *New Scientist*



the surface. The black symbols often had cracks that were about 4 micrometres wide and up to 20 micrometres deep, while the pale plastic backing typically had sparse and shallow ridging less than 1 micrometre deep. Even on signs lacking lichen growth, the cracks of the symbols often contain fungal filaments.

Lichenologists who study memorials are familiar with the exuberance of lichen growth on rough-hewn granite gravestones compared with the dearth of lichens on polished granite of similar age.

I propose that the microscopic roughness of the symbols on the sign (compared with their much smoother background) is the dominant factor causing them to be preferentially colonised by lichens.

Mike Follows

Sutton Coldfield, West Midlands, UK
Lichens are highly sensitive to their environment to the extent that they are used as an indicator of local pollution.

The road sign represents a



microhabitat, with its own microclimate that influences which lichen species thrive.

Some species can't tolerate high levels of sunlight, as would be the case for any lichen trying to colonise the white area of the sign. These species would be exposed to the reflected as well as the incident light – at least until they could fully cover an area and block off the reflection.

Brighter lichens are associated with higher levels of sunshine. The lichens in the photo look bright, so the sign may have a south-facing aspect and the lichens on the black area may already be at the maximum intensity of sunlight that they can tolerate. This means they wouldn't

be able to stray into the white area.

Alternatively, it is possible that the dark areas are warmer, during daylight at least, and this may favour some species. Most likely, a combination of factors is at play.

David Muir

Edinburgh, UK

Lichens consist of two or more symbiotic organisms, a fungus and its partners called photobionts – an alga and/or a cyanobacterium, which produce sugars by photosynthesis, supplying food for the fungus. The fungus builds the structure of the lichen, providing accommodation for the alga/cyanobacterium.

Titanium dioxide is a widely used white pigment in the paint industry as it efficiently scatters visible light, imparting whiteness, brightness and opacity to the paint. It also has antifungal properties. I suggest that the white paint on the road sign contains titanium dioxide or some other substance that happens to be a fungicide. Any incipient lichen growth on the white part of the sign is destined to die. ■

Answers

Quick quiz #149 Answers

- 1 Nereid
- 2 A liana
- 3 The small intestine
- 4 Tornadoes
- 5 Spinosaurus

Quick crossword #106 Answers

ACROSS 1 Starch, 4 Holdfast, 10 Empirical, 11 Paper, 12 Tail, 13 Stresemann, 15 Ufology, 16 Dosage, 19 Cement, 21 Trolley, 23 San Andreas, 25 Talc, 27 Magic, 28 Inception, 29 Cytosine, 30 Breech

DOWN 1 Spectrum, 2 Amphibole, 3 CERN, 5 Oilseed, 6 Depression, 7 Alpha, 8 Tyrant, 9 Scotty, 14 Copernicus, 17 Galvanise, 18 Hyacinth, 20 Torsion, 21 Trance, 22 Aseptic, 24 Night, 26 Spar

#164 Sum thing wrong Solution

$$\begin{array}{r} 1656 \\ +1076 \\ \hline =2732 \end{array}$$

It helps to replace the original "wrong" digits with letters, so that $ABCB + ADEB = FEGF$. Since $2B$ ends in F , F is even, so in the left column $2A = F$. A can't be 2, so can only equal 1, 3 or 4, meaning F is 2, 6 or 8, and B (which ends in F when doubled) is 6, 8 or 9. But $B + D$ must be less than 10 to avoid carrying 1 to the left column, and $B = 8$ or 9 both lead to dead ends, meaning $B = 6$, $A = 1$, $F = 2$ and the other numbers follow.

That's the way...

Few topics excite Feedback more than those that sit at the confluence of science and biscuits. So we salute researchers at the Massachusetts Institute of Technology who have synergistically integrated research and tea breaks by clamping creme-filled sandwich cookies to a device designed to investigate why, when you twist the two halves apart, the filling usually ends up attached almost entirely on one side rather than splitting evenly.

"Scientifically, sandwich cookies present a paradigmatic model of parallel plate rheometry in which a fluid sample, the cream, is held between two parallel plates, the wafers," we read in their paper "On Oreology, the fracture and flow of 'milk's favorite cookie'", a statement from which we do not presume to demur.

Their answer to the central question can best be summarised in the immortal words of hip hop mavens Run-DMC: "It's like that, and that's the way it is." They do find, however, that the filling of biscuits stored in conditions of higher temperature and humidity is more likely to split evenly between the two sides. This may explain the way the cookie crumbles in our stationery cupboard lair, and why there are crumbs everywhere.

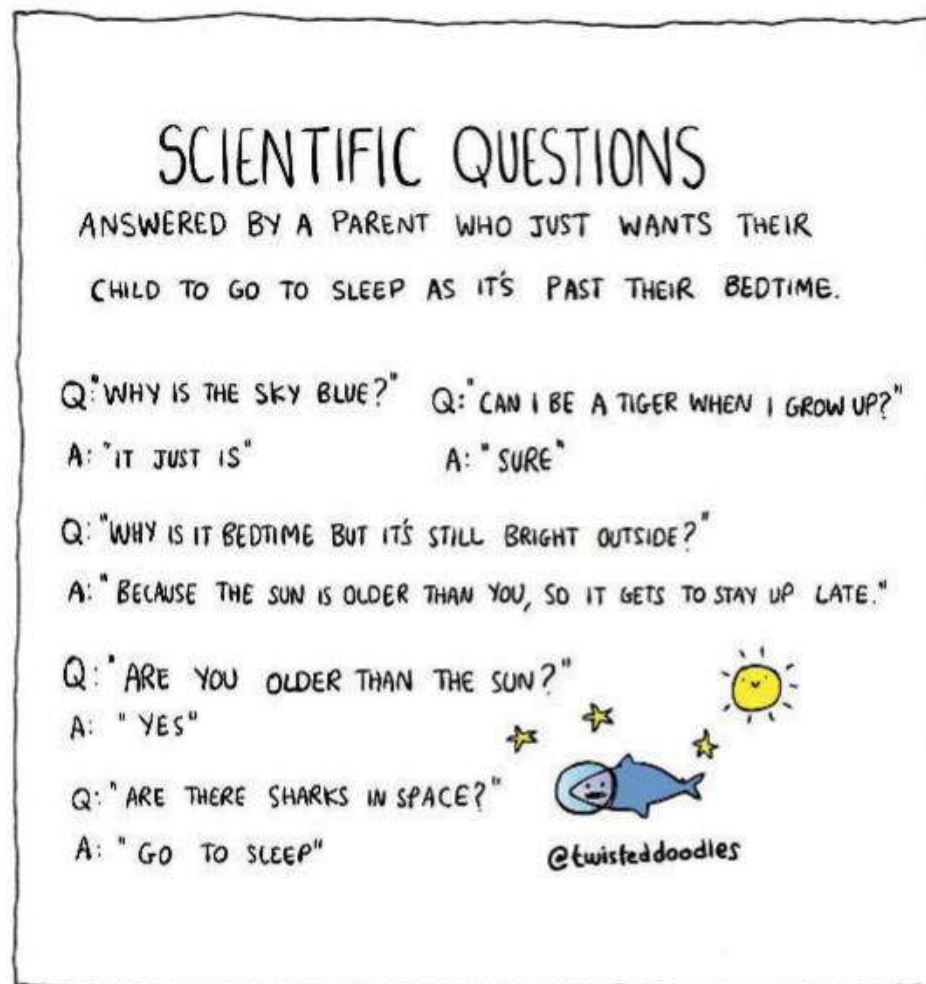
For those wishing to try this at home, and also investigate the effects of dunking in liquid on biscuit integrity, the paper comes with 3D printer design files and suggestions for your own "Oreometer" tests. That is our next few tea breaks sorted.

...the cookie crumbles

Correction: few topics excite Feedback more than those at the confluence of science, biscuits and tax law, as UK judges rule that flapjacks are, among other things, "too chewy" to count as cakes.

The UK judiciary has long been at the cutting edge of objective definitions of cake, owing to UK tax law treating biscuits as sweets, and therefore luxury items to be taxed

Twisteddoodles for New Scientist



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at normal rates, but cake – quite rightly – as an essential foodstuff that is zero-rated for tax purposes. Previous rulings have concerned Jaffa Cakes, oblate sweetmeats with a gooey orangey filling (cakes), and snowballs, marshmallow domes coated in chocolate and/or coconut (also cakes).

The latest judgment from a two-person judicial tasting panel, confusingly referred to as a tribunal – presumably a reduced-calorie version – is a masterclass in integrating considerations as disparate as chemistry, rheology, morphology and behavioural and cultural science. Besides being too chewy, inadequately aerated, insufficiently square and too protein-rich to count as cake, the flapjack bars were deemed by the justices to "look wholly out of place as a dessert at the end of a meal, or as the food

to be consumed at an afternoon tea". In these parts, you don't get more damning than that.

Peep show

How many Peeps would it take to fill the Grand Canyon? Another question for our pile of ones we had not thought to ask, partly but not exclusively through not knowing what Peeps are. Our cultural ignorance: they are famed US Easter treats "made from what looks (and tastes) like artificial foam rubber", according to our informant Bob Willis, presumably not the late England fast bowler. The answer, according to the article he sends, is 127 quadrillion, which also merits an entry in our burgeoning pile of mystifying size comparisons. Peeps small, Grand Canyon large, we think is the general idea. Good luck to anyone intent on verifying that one.

Delicious dairy

Christina Kenny from London writes concerning a statement in *New Scientist's* article on breastfeeding practices in the 19th-century Netherlands (23 April, p 10), "The researchers wanted to find out more about the diets of the women and children in this village, which mainly consisted of dairy farmers at this time". "Eye-opening feature on Dutch cannibalism," she observes. Our own eyes briefly pop, and then narrow again. You know perfectly well what we meant.

Potter off

Also disappointed is Tillmann Benfey from Fredericton in New Brunswick, Canada, who castigates a failure in an article on divergent animal evolution in urban and rural settings (12 March, p 42) to cite a seminal account from over a century ago. Apologies. The full reference is Potter, B. *The Tale of Johnny Town-Mouse* (1918).

An accelerator writes

Feedback is startled to be sent an email by the Large Hadron Collider. Either the particle smasher has received startling new powers in its recent upgrade, or a beech marten has chewed through a key cable making things go haywire again, as in 2016.

We are even more confused to find that the Large Hadron Collider is writing to ask "Did you write The Large Hadron Collider?". No, on so many levels. It turns out to come from an academic social networking site of the type some of you have previously spotted claiming Charles Darwin is still alive and working at a university in South America, and that the equally long-late biologist Jean-Baptiste Lamarck has just mentioned you in a paper (5 December 2020). We briefly consider the possibility that all these messages are coming from another dimension, before deciding the answer is still "no". ■

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2 FOR £12**

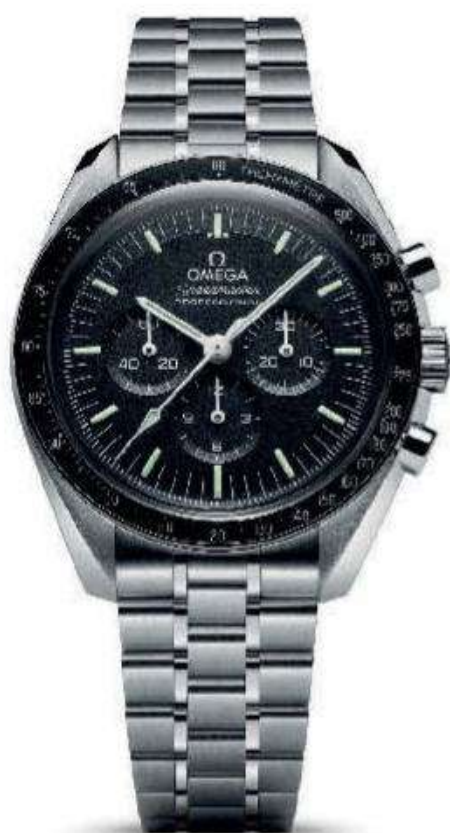
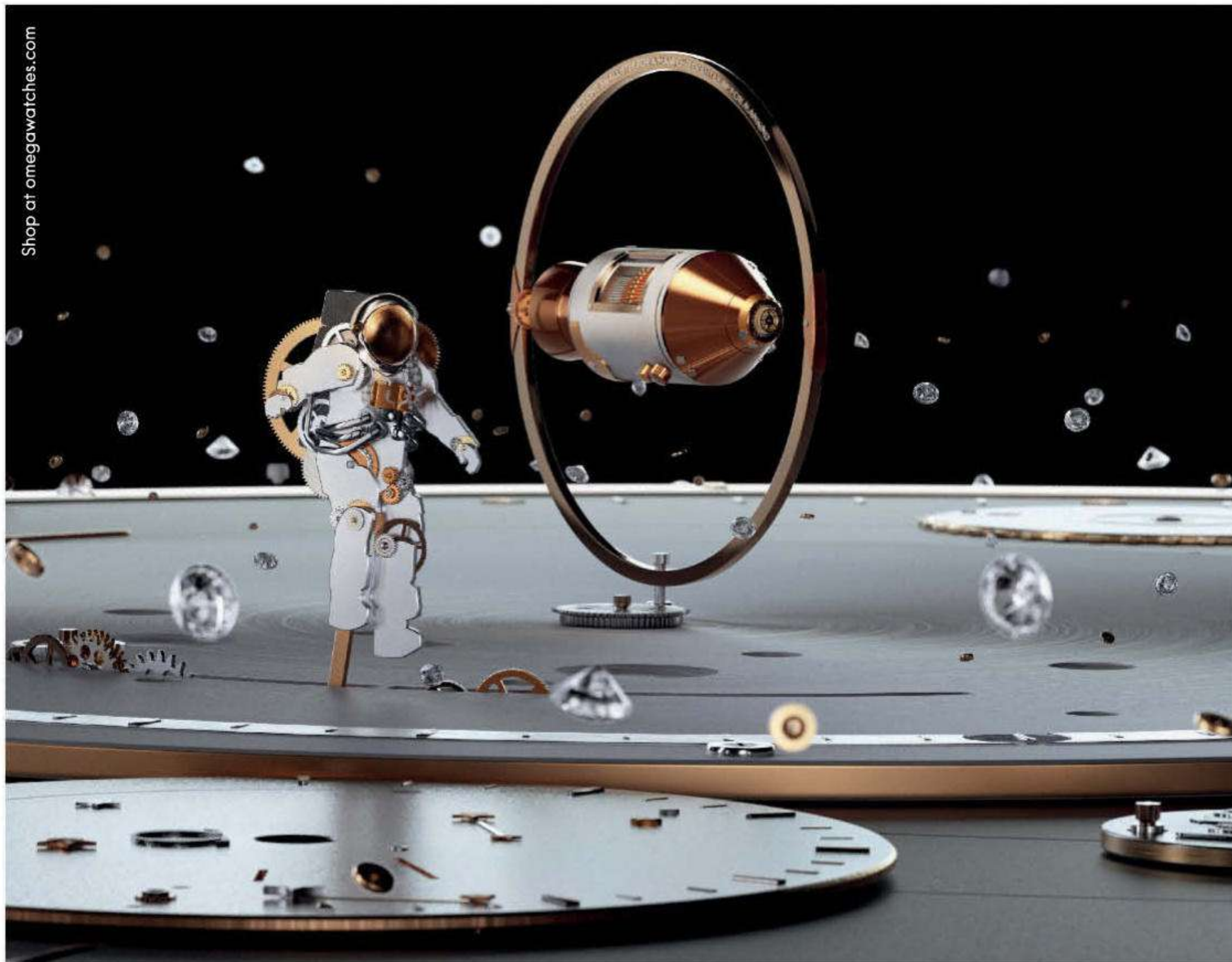


BLACK OR BROWN

1" wide with smart buckle & neat edge
stitching Waist Size:

32/34, 36/38, 40/42, 44/46, 48/50, 52/54

Order style AA007



SPEEDMASTER MOONWATCH
CO-AXIAL MASTER CHRONOMETER

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Although not your typical watch interior, our dreamlike world is not too far removed from the real thing. An OMEGA watch calibre is a tiny universe of components. Each working so wonderfully together, our precision timepieces have earned the trust of athletes, deep-sea adventurers – and even astronauts.


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